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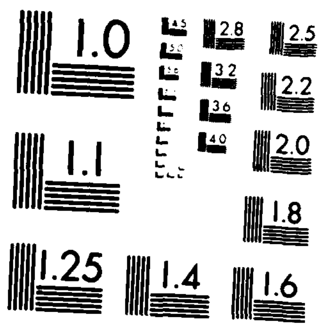

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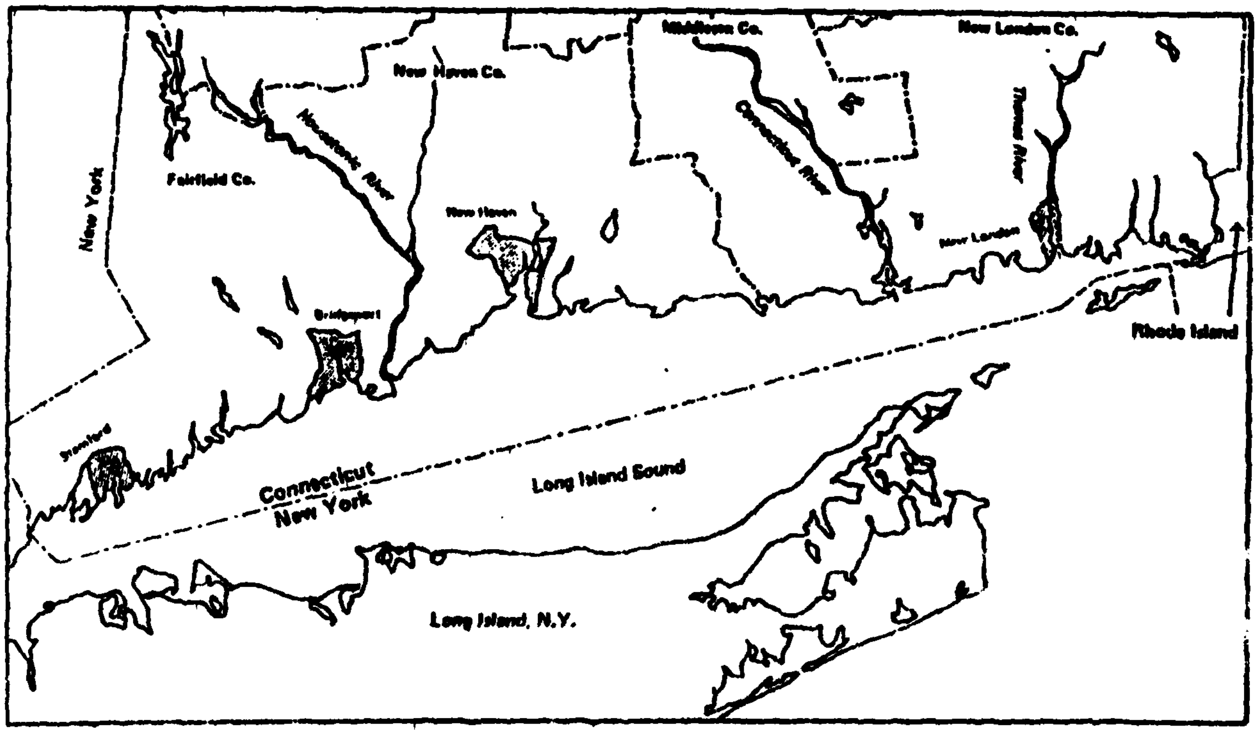
The scope of this study includes consideration of material dredged from Connecticut harbors only. The preliminary siting of containment facilities include only the locations on the Connecticut side of the sound. The study extends inward along the Housatonic, Connecticut, and Thames Rivers to the upstream limits of their respective Federal channels. There was a 50 year design life used for containment facility sizing and two types of channel maintenance and construction were considered: (1) Federal project and (2) Other projects allowed under Federal permit.

This study has been concerned with large volume containment alternatives for long-term dredged material disposal in LIS.

Reconnaissance Report:

Dredged Material Containment In Long Island Sound



U.S. ARMY CORPS of ENGINEERS

NEW ENGLAND DIVISION
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

JANUARY 1979

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Preface and Acknowledgements

This is a report of a Stage 1 study to prepare an overview assessment of the feasibility of large-volume containment of material dredged from Connecticut harbors along Long Island Sound. Specifically, containment to create shoreline land extensions; nearshore, shallow water islands; and offshore, deep water islands in the Sound has been assessed. A primary objective of the study was identification of further work areas to be pursued during Stage 2 of the Long Island Sound containment study.

As might be expected, there is much to be done before a definitive evaluation of containment for land creation, island creation, or any other purpose can be made. In this report, an overview of Stage 2 presents (1) an approach to the formulation of alternative containment plans, and (2) a framework for plan impact assessment and evaluation. Problem identification and plan formulation through local public involvement (workshops), interagency coordination, and internal NED planning will be an important part of the early Stage 2 effort.

The study was performed under contract by Energy Resources Co. Inc., Cambridge, Massachusetts, and Sasaki Associates, Inc., Watertown, Massachusetts. The contract was directed by John Gushue, principal investigator, of Energy Resources. Project staff from Energy Resources were Patricia Schettig and Steven Fischer. Project coordinator for Sasaki Associates was Kenneth Kreutziger, who was assisted by Maurice Freedman, William Firth, and Richard Westcott.

The study was conducted under the supervision of Raymond Boyd, Planning Division/Coastal Development Branch, New England Division of the Corps of Engineers.

RECONNAISSANCE REPORT ON DREDGED
MATERIAL CONTAINMENT IN LONG ISLAND SOUND

SECTION ONE: INTRODUCTION

Long Island Sound (LIS) has been used as a disposal site for dredged material and other urban-industrial wastes for more than 100 years. Management of disposal activities in the Sound began in 1888 when the Port Supervisors Act prohibited disposal outside of designated areas. Since then, the 19 sites identified in Figure 1-1 have been used for dredged material disposal at one time or another. Today, only three of these sites are still in use--New Haven, Cornfield Shoals, and New London--and a fourth site planned for the western portion of the Sound is under study. Future dredged material management plans will undoubtedly be designed to further centralize, as well as minimize, open water disposal in the Sound.[1]

In concept, there are many alternatives to open water disposal including those listed in Table 1-1. Project-specific factors such as costs and funding sources, environmental impacts, dredged material characteristics, and public opinion determine their feasibility in any given dredging situation. This report presents the results of an investigation of the feasibility of containment alternatives for material dredged from Connecticut harbors along LIS. Specifically, containment for the creation of shoreline land

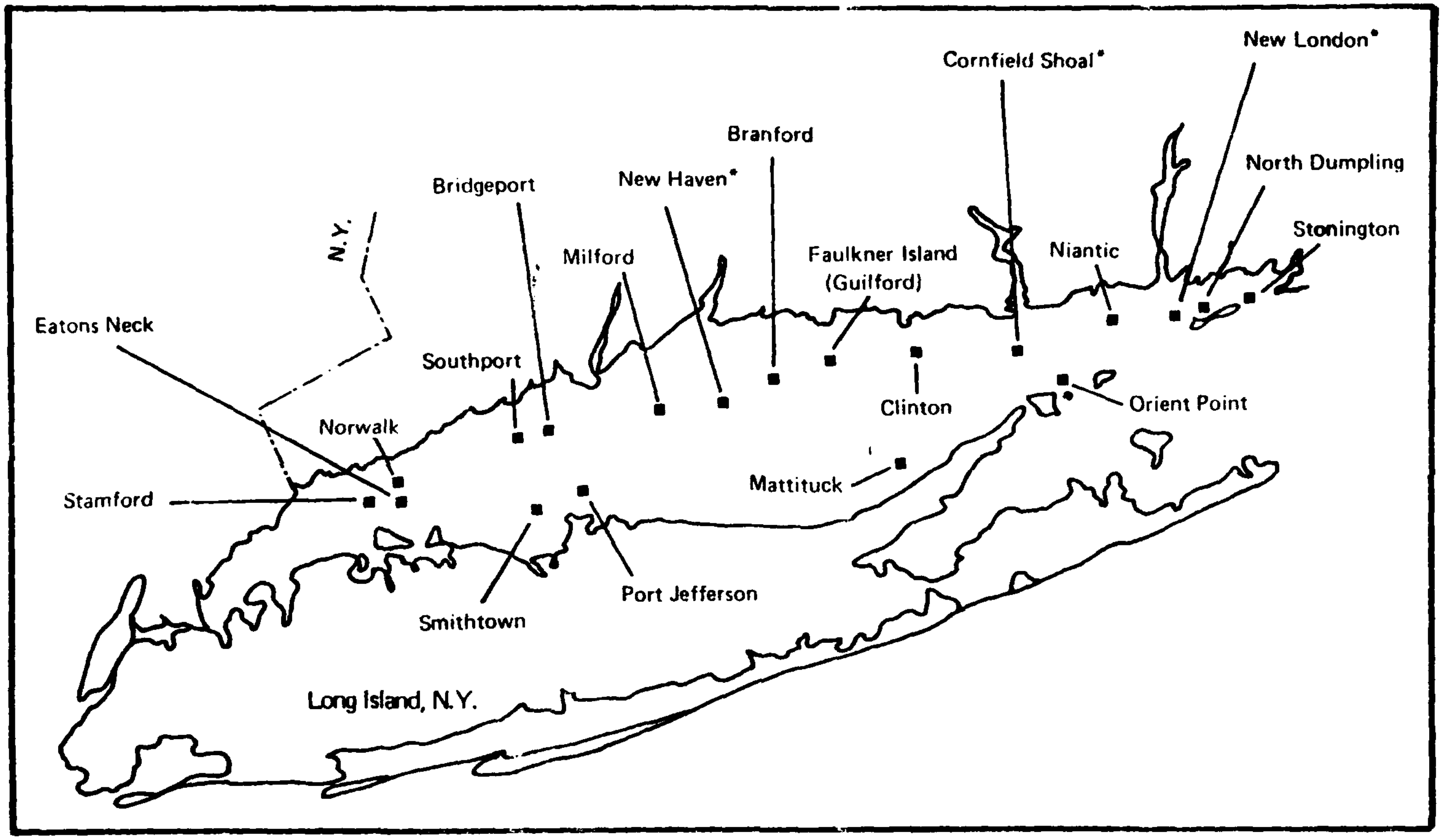


Figure 1--1. Historical dredged material disposal grounds in Long Island Sound (* Denotes sites still active)

TABLE 1-1

DREDGED MATERIAL DISPOSAL ALTERNATIVES

---

1. Aquatic disposal

   - open ocean dumping
   - subacueous borrow pits

2. Beach nourishment

3. Habitat development projects

   - marsh creation
   - aquatic habitat
   - terrestrial habitat
   - island habitat

4. Contained disposal

   - rehandling basin prior to use of material in construction or agriculture
   - creation of waterfront land for ultimate development for industrial, recreational, etc. purposes
   - creation of islands for ultimate development for industrial or recreational use
   - creation of "container island" for long-term use as disposal area

5. Other

   - product development
   - strip mine reclamation
   - agricultural medium
   - sanitary landfill cover material
   - incineration

---

extensions; nearshore, shallow water islands; and offshore, deep water islands has been assessed.

Purpose and Authority

The project was undertaken as part of the New England Division Corps of Engineers' Stage 1 planning effort to develop a plan of study for dredged material containment in LIS. Recommendations for more detailed and site-specific analysis of potentially feasible containment options are presented at the end of this report. The project was authorized by a Resolution adopted on 10 May 1977 by the Committee on Public Works and Tranportation of the U.S. House of Representatives. The Resolution, requested by Connecticut Congressmen McKinney, Giaimo, and Dodd, read as follows:

> Resolved by the Committee on Public Works and Transportation of the House of Representatives, United States, that the Board of Engineers for Rivers and Harbors is hereby requested to review the reports on the Land and Water Resources of the New England-New York Region, published as Senate Document Numbered 14, Eighty-fifth Congress, First Session, and other pertinent reports, with a view to determining the feasibility and impacts of the treatment and use of the dredged materials to result from the continued maintenance and anticipated improvements of Long Island Sound harbors, as well as from any newly created Federal harbors, to build artificial islands in Long Island Sound for recreation, conservation, marsh building, development, and other purposes. The study should also

consider the utilization of dredged materials from projects other than Federal (i.e., State, community, and private), and the feasibility and acceptability of utilizing solid wastes other than dredged materials for island building.

Project Scope

Stage 1 planning is by definition a preliminary iteration of the four major tasks of problem identification, formulation of alternatives, impact assessment, and evaluation.[2] The desired Stage 1 output -- a plan for subsequent Stage 2 and 3 planning and design -- requires an overview approach in which all factors relevant to the problem are identified and incorporated into the plan of study. As a consequence, detailed impact assessments and evaluations are not made. Instead, the relative significance of the various factors involved is assessed, often qualitatively. An overview approach was followed in this study, as the descriptor "reconnaissance report" implies.

The scope of the project was limited to include consideration of containment of material dredged from Connecticut harbors only. Dredging in New York harbors was not considered. In the preliminary siting of containment facilities, only locations on the Connecticut side of the Sound were included. Hence, the project study area is defined by the Connecticut coastline and the New York-Connecticut border in the center of the Sound. The study area also extends inward along the Housatonic, Connecticut, and Thames Rivers to the upstream limits of their respective Federal channels. For

convenience, the study area was divided into three coastal areas as shown in Figure 1-2.

Within the study area, dredged material from two types of channel maintenance and construction projects was considered: (1) Federal projects authorized by Congress; and (2) other projects allowed under Federal permit. Historical data on both types of projects were compiled from Corps of Engineers files, and projections of future dredged quantities were made. The possibility of containing other solid wastes along with dredged material for island/land creation was also considered.

For containment facility sizing and costing, a 50-year design life was used. To account for a probable extensive period of siting analysis, feasibility evaluation, environmental review, design and construction, it was assumed that contained disposal would begin in 1985. Therefore, projections of the amounts of material to be contained were made for the period from 1985 to 2035. Average annual quantities were estimated for Corps projects and for other projects under Federal permit.

The containment analysis was performed with the primary objective of establishing ballpark costs of "container islands" for long-term use for disposal of dredged material from several harbors. To illustrate a range of concepts, containment facilities were sized for the following design cases:

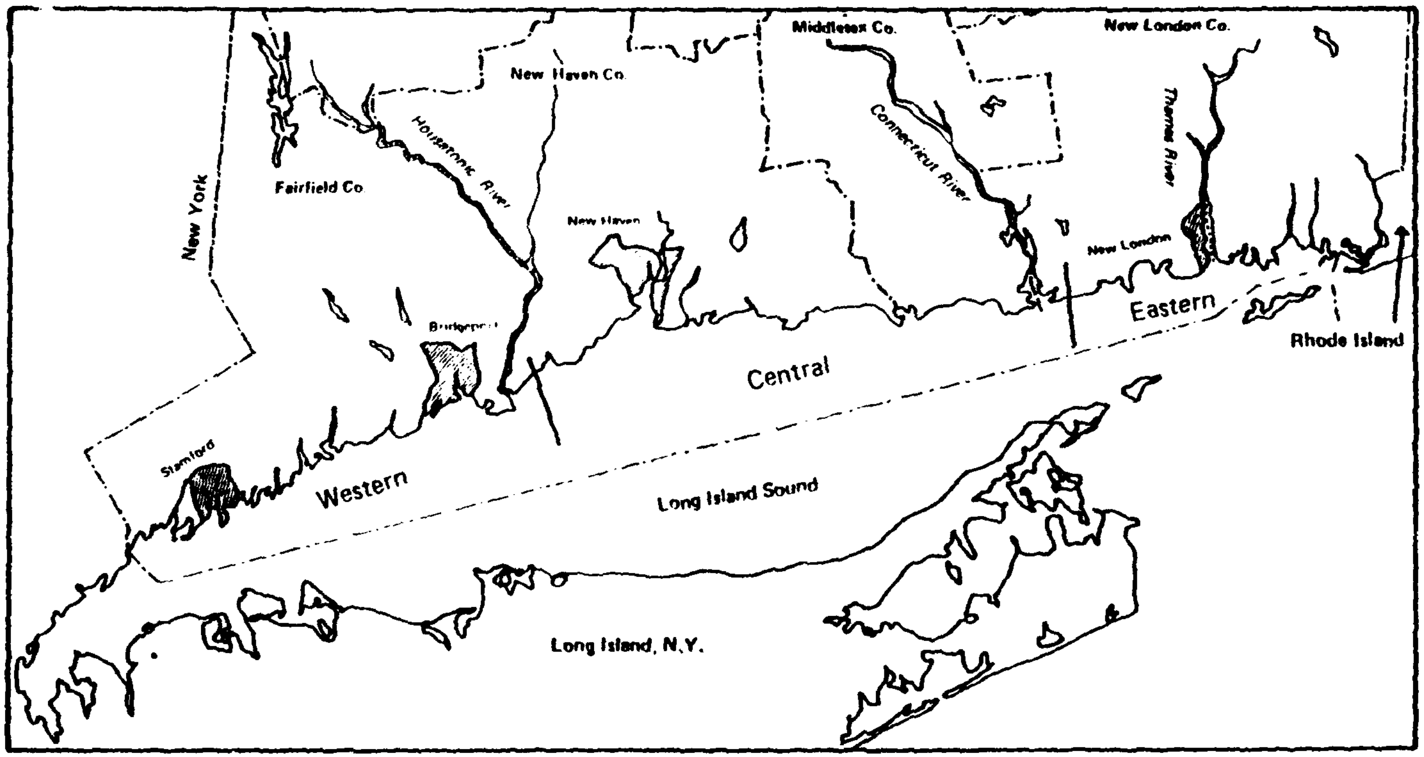


Figure 1–2. Connecticut coastal areas.

1. A single facility to receive all dredged material projected for the entire study area from 1985 to 2035.

2. Three facilities to receive all dredged material projected for each of the three Connecticut coastal areas from 1985 to 2035. One facility would be located in each coastal area.

With respect to facility siting, three types of projects and siting zones were assumed: (1) shoreline extensions in water depths of up to 6 feet mean low water (mlw); (2) near-shore islands in water depths of up to 18 feet mlw; and (3) offshore islands in water depths of up to 54 feet mlw. Using average water depths in each siting zone and an assumed final fill elevation based on structural design criteria, the containment structures required in each design case were sized and costed.

The containment concepts developed in this report do not represent site-specific designs such as would be prepared during Stages 2 and 3. However, consideration was given to facility siting. Preliminary criteria for land/island creation projects were formulated and used to identify potential facility locations. An informal workshop attended by representatives of several relevant State of Connecticut agencies provided initial State reaction to the potential facility locations as well as to the containment option in general.

Prior Studies and Reports

Dredged material management in the LIS region has been the subject of considerable study in recent years. Those reports most relevant to the project at hand include:

1. McAleer, John, "Artificial Islands and Platforms in Long Island Sound," prepared for the Long Island Sound Regional Study, New England River Basins Commission, New Haven, Connecticut, and Boston, Massachusetts, June 1974.

2. State of Connecticut, Department of Environmental Protection, Dredging and Dredged Spoil Disposal in Long Island Sound: A Discussion Paper, Hartford, Connecticut, October 1975.

3. State of Connecticut, Department of Environmental Protection and State of New York, Department of Environmental Conservation, Interim Program for the Disposal of Dredged Material in Long Island Sound, April 1977.

Scientific papers and reports on the ecology of LIS are abundant in the literature, and harbor-specific environmental assessments and feasibility reports prepared by the New England Division are also available. However, the literature specifically related to contained disposal in LIS is limited to the reports listed above. Many reports published by the Corps of Engineers Waterways Experiment Station in Vicksburg, Mississippi under the recently concluded Dredged Material Research Program are

very useful state-of-the-art documents on dredged material management.

Coordination

During the course of this reconnaissance effort, telephone and in-person discussions were held with representatives of several cognizant State and Federal agencies. The individuals identified below were contacted for information and personal opinion relating to dredged material containment in LIS:

1. U.S. Environmental Protection Agency
   Region I
   Boston, Massachusetts

   Peter Holmes, Permits

   Ira Leighton, Solid Waste

2. U.S. Department of Commerce
   National Marine Fisheries Service
   Milford, Connecticut

   Michael Ludwig

3. U.S. Department of the Interior
   Fish and Wildlife Service

   Ralph Tiner

   Robert Scheirer

   Robert Curry

4. U.S. Department of Defense
   Corps of Engineers, Waterways Experiment Station
   Vicksburg, Mississippi

   Thomas Patin

   Hanley Smith

   L. Jean Hunt

5. U.S. Department of Defense
   Corps of Engineers
   Buffalo District
   Buffalo, New York

   Joseph Foley, Chief - Design Branch

6. State of Connecticut
   Department of Environmental Protection

   Glen Gross, Coastal Area Management

   Robert Leach, Coastal Area Management

   Hugo Thomas, Natural Resources

   Denis Cunningham, Water Resources

   John Jeffrey, Water Resources

   Ronald Whitehour, Water Resources

   Jonathan Clapp, Planning and Coordination

   Thomas Hoehn, Marine Regulation

   Ernest Beckwith, Marine Regulation

   Robert Jones, Marine Regulation

   Fred Bauach, Water Compliance

   Robert Nichols, Solid Waste

   Dennis DeCarli, Fish and Wildlife

7. State of Connecticut
   Office of Policy and Management

   Richard Symonds

   Harold Ames

8. State of Connecticut
   Department of Agriculture

   John Baker, Aquaculture Division

9. New England River Basins Commission

   Irv Waitsman, Planning Director

10. Dredging and Construction Contractors

Michael Reich, Great Lakes Dredge and Dock, New York City

Chris Kirk, Gibson and Cushman Dredging Co., Long Island

Richard Rex, Perini Construction Corp., East Boston, Mass.

Sean Kiniry, A.H. Harris and Sons, Medfield, Mass.

Carl Caskadon, U.S. Steel, New Jersey

Many of the State of Connecticut personnel listed above participated in an informal project review session held in October 1978 at the Coastal Area Management offices in Hartford. The preliminary nature of this planning effort would not allow any official State agency positions on containment facility planning and siting to be formed. However, many needed analyses associated with containment in LIS were brought out in discussion and these are reflected in the recommendations for further study presented at the end of this report.

As the formulation and evaluation of containment alternatives for LIS proceeds during Stage 2 planning, an extensive public involvement program is envisioned. In addition to public hearings to consider alternative plans, a series of workshops to obtain local input during plan formulation are to be organized. These workshops will enable local governments and the public-at-large to work closely with Corps planners and engineers in evaluating containment as a disposal option.

SECTION TWO: HISTORICAL AND PROJECTED DREDGING ACTIVITY

The two major sources of dredged material in Connecticut are: (1) channel maintenance and construction projects done by the Corps of Engineers; and (2) various dredging/disposal projects done by other governmental agencies and the general public under Federal permits issued by the Corps. Historical data on Corps and non-Corps permitted dredging and disposal compiled from New England Division files is summarized below. This historical perspective is then used, along with tentative Corps construction and maintenance plans, to estimate future dredged material volumes.

Federal Projects

At present there are 27 Federal harbor projects authorized in Connecticut. These projects are identified in Table 2-1 and their locations are shown in Figure 2-1. A complete inventory of Corps of Engineers improvement and maintenance dredging in Connecticut from 1947 through 1977 is provided in Table A-1 of Appendix A.

Improvement Dredging

Improvement (new work) dredging in Connecticut harbors has been extremely rare in the past 15 years, consisting only of a 76,000 cubic yard (CY) project in Stony Creek

TABLE 2-1

FEDERAL PROJECTS IN CONNECTICUT

Western Coastal Area

1. Greenwich Harbor
2. Mianus River
3. Stamford Harbor
4. Westcott Cove
5. Fivemile River Harbor
6. Wilson Point Harbor
7. Norwalk Harbor
8. Wesport Harbor and Saugatuck River
9. Southport Harbor
10. Bridgeport Harbor
11. Housatonic River

Central Coastal Area

12. Milford Harbor
13. Breakwaters at New Haven
14. New Haven Harbor
15. Branford Harbor
16. Stony Creek
17. Guilford Harbor
18. Clinton Harbor
19. Duck Island Harbor
20. Patchogue River
21. Connecticut River below Hartford

Eastern Coastal Area

22. Niantic Bay and Harbor
23. New London Harbor
24. Thames River
25. Mystic River
26. Stonington Harbor
27. Pawcatuck River

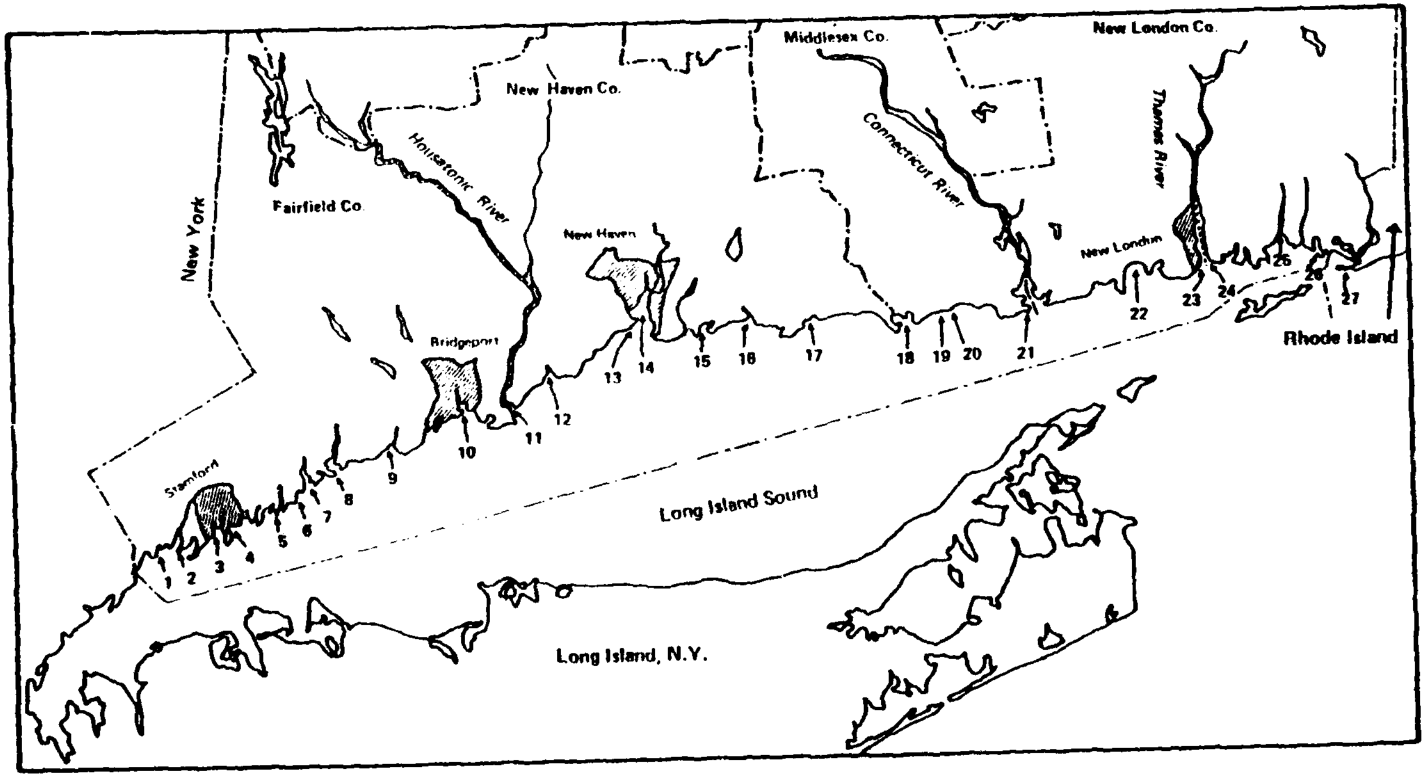


Figure 2–1. Federal projects in Connecticut.

in 1969 and a 31,000 CY job in Niantic Bay and Harbor during 1970. By comparison, the U.S. Navy in New London received a 1974 Federal permit for a deepening project involving 2.8 million cubic yards (MCY) of material. The New England Division has several improvement projects on the drawing board and these are listed in Table 2-2. For the purpose of projecting dredged material volumes for the 50-year period from 1985 to 2035, the average annual maintenance volumes associated with the planned improvements have also been estimated and included in Table 2-2.

Maintenance Dredging

The Corps of Engineers maintenance dredging program in Connecticut has been much more active than the improvement program, especially in the central coastal area. For the 10-year period from 1968 to 1977, Corps total maintenance dredging has been distributed as follows: western coastal area -- 391,600 CY; central area -- 2.51 MCY; eastern area -- 12,810 CY. In contrast, according to tentative plans for maintenance during the next 10 years from 1978 to 1987, the total maintenance volume distribution will become: western area -- 1.2 MCY; central area -- 1.6 MCY; and eastern area -- 340,000 CY. The data on historical and planned maintenance activity for each Federal project in Connecticut, along with long-term projections, are provided in Table 2-3. To make the projections for the period 1985 to 2035, estimates of the number of maintenance projects to be undertaken in each Federal navigation project and the average volume dredged per maintenance project were made as indicated in Table 2-3.

TABLE 2-2

FEDERAL IMPROVEMENT PROJECTS UNDER CONSIDERATION IN CONNECTICUT[a]

CONNECTICUT COASTAL AREA	PROJECT	DATE	ESTIMATED VOLUME (CY)	AVERAGE ANNUAL MAINTENANCE
Western	Bridgeport Harbor	1984	2,500,000	25,000
	Black Rock Harbor	1985	150,000	2,000
Central	New Haven Harbor	1983-86	7,200,000	72,000
	Clinton Harbor	1980	230,000[b]	2,500
	Patchogue River	1982	30,000[b]	1,000
Eastern	New London Harbor	1983	1,600,000	50,000
Total New Work (1985-2035)			11,450,000	152,500

[a]Data provided by Coastal Development Branch, Planning Division, New England Corps of Engineers.

[b]Not included in 1985-2035 estimate.

TABLE 2-3

FEDERAL PROJECT MAINTENANCE: HISTORICAL, PLANNED THROUGH 1987, AND PROJECTED FROM 1985 TO 2035

		HISTORICAL MAINTENANCE (1948-77)				PLANNED MAINTENANCE (1978-1987)[a]		PROJECTIONS (1985-2035)					
CONN. COASTAL AREA	PROJECT	NO. PROJ-ECTS	FREQ. (YR)	AVERAGE VOL. PER PROJECT	YEAR LAST DREDGED	YEAR	VOLUME	NO. PROJ-ECTS	DATE OF 1st PROJ.	AVERAGE VOL. PER PROJECT	AVERAGE ANNUAL VOLUME	50-YR CUMULATIVE QUANTITY	YEARS BETWEEN PROJECTS
Western Coastal Area (including Housatonic River)	Greenwich Harbor	1	-	39,800	1968	1983	50,000	4	2000	50,000	4,000	200,000	15
	Mianus River	1	-	19,730	1964	1981	35,000	4	1995	35,000	2,800	140,000	15
	Stamford Harbor	1	-	121,250	1963	1981	150,000	4	2000	150,000	12,000	600,000	15
	Westcott Cove	1	-	8,500	1963	1978 1986	20,000 20,000	7	1986	20,000	2,800	140,000	10
	Fivemile River Harbor	1	-	47,700	1968	1982	70,000	4	1995	70,000	5,600	280,000	15
	Norwalk Harbor	5	5	124,430	1969	1979	200,000	7	1990	200,000	28,000	1,400,000	10
	Westport Harbor and Saugatuck River	1	-	25,870	1970	1983	80,000	6	1995	80,000	9,600	480,000	10
	Southport Harbor	2	14	36,690	1962	1982	50,000	4	1995	50,000	4,000	200,000	15
	Bridgeport[b] Harbor	6	2-3	227,000	1960	1981 1982	200,000 150,000	4	1995	225,000	18,000	900,000	15
	Housatonic River	3	16	173,660	1976	1984	200,000	7	1985	200,000	28,000	1,400,000	10
Western Area Totals								51			114,800	5,740,000	

[a]Data provided by Carl Boutilier of New England Corps (tentative plan).

[b]Average annual maintenance includes 27,000 cy/yr after new work to be done in 1984 in Bridgeport and Black Rock Harbors.

TABLE 2-3 (CONT.)

CONN. COASTAL AREA	PROJECT	HISTORICAL MAINTENANCE (1948-77) NO. PROJECTS	FREQ. (YR)	AVERAGE VOL. PER PROJECT	YEAR LAST DREDGED	PLANNED MAINTENANCE (1978-1987)[a] YEAR	VOLUME	PROJECTIONS (1985-2035) NO. PROJECTS	DATE OF 1st PROJ.	AVERAGE VOL. PER PROJECT	AVERAGE ANNUAL VOLUME	50-YR CUMULATIVE QUANTITY	YEARS BETWEEN PROJECTS
Central Coastal Area (including Connecticut River)	Milford Harbor	3	9-10	42,860	1967	1982	100,000	4	1995	100,000	8,000	400,000	15
	New Haven[c] Harbor	14	1-2	225,950	1977	None		25	1985	300,000	150,000	7,500,000	2
	Branford Harbor	3	10	85,870	1976	1985	100,000	7	1985	100,000	14,000	700,000	10
	Stony Creek Harbor	1	-	32,930	1977	1984	35,000	7	1985	35,000	4,900	245,000	10
	Guilford Harbor	2	10	80,000	1974	1984	70,000	7	1985	70,000	9,800	490,000	10
	Clinton[d] Harbor	4	6-7	29,200	1976	None		7	1985	30,000	4,200	210,000	10
	Duck Island Harbor	1	-	132,540	1949	None		2	1985	100,000	4,000	200,000	25
	Patchogue[e] River	4	6-7	33,100	1977	1983	100,000	7	1990	50,000	7,000	350,000	10
	Connecticut River below Hartford	17	2-3	182,370	1977	1979 1981 1983 1985 1987	200,000 200,000 200,000 250,000 300,000	25	1985	300,000	150,000	7,500,000	2
Central Area Totals								101			351,900	17,595,000	

[c]Average annual maintenance includes 72,000 cy/yr after new work to be done in 1983-86.
[d]Average annual maintenance includes 2,500 cy/yr after new work to be done in 1980.
[e]Average annual maintenance includes 1,000 cy/yr after new work to be done in 1982.

TABLE 2-3 (CONT.)

CONN. COASTAL AREA	PROJECT	HISTORICAL MAINTENANCE (1948-77) NO. PROJECTS	FREQ. (YR)	AVERAGE VOL. PER PROJECT	YEAR LAST DREDGED	PLANNED MAINTENANCE (1978-1987)[a] YEAR	VOLUME	PROJECTIONS (1985-2035) NO. PROJECTS	DATE OF 1st PROJ.	AVERAGE VOL. PER PROJECT	AVERAGE ANNUAL VOLUME	50-YR CUMULATIVE QUANTITY	YEARS BETWEEN PROJECTS
Eastern Coastal Area (including Thames River	Niantic Bay and Harbor	None	-			1981	40,000	7	1990	40,000	5,600	280,000	10
	Thames River	4	6-8	157,880	1966	1982	200,000	4	1995	200,000	16,000	800,000	15
	New London Harbor[f]	None	-			None		25	1985	100,000	50,000	2,500,000	2
	Mystic River	1	-	17,200	1956	None		2	1985	50,000	2,000	100,000	25
	Stonington Harbor	None	-			None		None					
	Pawcatuck River	3	15	17,560	1977	1984	100,000	7	1985	50,000	7,000	350,000	10
Eastern Area Totals								20			80,600	4,030,000	

[f]Average annual maintenance includes 50,000 cy/yr after new work to be done in 1984.

Summary: Projected Federal Dredging

The Federal portion of the dredged material expected to be generated in Connecticut during the 50-year period from 1985 to 2035 is estimated to be about 39 MCY. Over 70 percent of this volume will be due to maintenance projects and 64 percent will originate in the central coastal area. A complete breakdown of the projected Federal dredging is given in Table 2-4.

TABLE 2-4

PROJECTED FEDERAL DREDGING, 1985 TO 2035

COASTAL AREA	IMPROVEMENT	MAINTENANCE	TOTALS	PERCENT
Western	2,650,000	5,740,000	8,390,000	22
Central	7,200,000	17,595,000	24,795,000	64
Eastern	1,600,000	4,030,000	5,630,000	14
Totals	11,450,000	27,365,000	38,815,000	100

Federal Disposal

Analysis of the disposal methods data in Table A-1, Appendix A reveals that open water disposal has been preferred in most Federal projects since 1948. Except for the Connecticut River below Hartford project, land disposal has been used only on an infrequent basis. In the 10-year period from 1968 to 1977, however, nearly 40 percent of the material dredged from Federal projects was disposed on land. This recent trend, shown in Table 2-5, is somewhat misleading

TABLE 2-5

DISPOSAL METHODS FOR CORPS OF ENGINEERS DREDGING IN CONNECTICUT (1968-1977)

CONNECTICUT COASTAL AREA	TOTAL VOLUME 1968-1977[a]	DISPOSAL METHOD AND PERCENT OF TOTAL					
		LAND	%	OPEN WATER	%	SIDE-CAST	%
Western	391.6	215.0	55	176.6	45	0	0
Central	2,588.2	956.0	37	1,613.1	62	19.1	<1
Eastern	43.8	0	0	31.0	71	12.8	29
Totals[b]	3,023.6	1,171.0	39	1,820.7	60	31.9	<1

[a]Volumes are in thousand cubic yards.
[b]Totals have been rounded off.

because (1) the western area data are dominated by land disposal of 215,000 CY of material from a 1976 maintenance job in the Housatonic River, and (2) the central area data are dominated by the Connecticut River below Hartford project, the most active project in the Division and the one in which land disposal is most often used. About 73 percent of the land disposal in the central area is attributable to the Connecticut River project.

During the data collection phase of this study, an effort was made to pinpoint the historical land disposal sites for each project. Although hampered by incomplete records, land disposal locations were noted for six projects done since 1948. These land disposal sites can be seen in Apendix B, which contains Corps of Engineer project maps on which the site locations have been indicated.

Federal Dredging/Disposal Costs

The costs of Federal improvement and maintenance dredging projects, as indicated by contractor cost data obtained from Corps files, have risen steadily since 1948. This expectd trend is shown in Table 2-6 on a per cubic yard basis. The overall upward trend is evident regardless of disposal method. It is true, however, that land disposal sites used in Connecticut have not involved expensive containment structures and this is undoubtedly reflected in the observed cost trends. Project-specific cost data are included in Table A-1 of Appendix A.

TABLE 2-6

COSTS OF FEDERAL DREDGING IN CONNECTICUT (1947-1977)

	IMPROVEMENT			MAINTENANCE		
		COST PER CY			COST PER CY	
TIME PERIOD	# OF PROJECTS	AVERAGE	RANGE	# OF PROJECTS	AVERAGE	RANGE
1948-59	18	$0.64	$0.22-1.33	21	$1.22	$0.53-3.20
1960-69	6	1.14	0.63-2.10	28	1.40	0.36-3.13
1970-77	1	2.88	NA	18	2.98	0.92-5.54

Other Projects Under Federal Permit

Over the 10 years from 1968 to 1977, non-Corps dredging/disposal activity in Connecticut generated more than twice the material volume attributable to the Corps. Even when the 2.88 MCY New London improvement project, started in 1974 by the U.S. Navy, is excluded, the non-Corps volume is greater than the Corps volume. A summary of the permitted dredging/disposal activity since 1968 is given in Table 2-7 and a complete inventory of projects is provided in Appendix C.

As in the case of Federal projects, non-Corps dredging activity is highest in the central coastal area, averaging 226,000 CY per year since 1968. For the entire coast, about 402,000 CY per year have been dredged on the average, again excluding the large Navy project in New London. The annual averages computed for each coastal area since 1968 have been used to estimate the non-Corps dredging activity for the 50-year period from 1985 to 2035 at about 20 MCY. Over 56 percent of this volume will originate in the central area, as indicated in Table 2-8.

Overall, the preferred disposal method for permitted projects since 1968 has been land disposal, although open water disposal has been favored in the western and eastern coastal areas. This is seen in Table 2-9. It is safe to assume that land disposal method includes using the dredged material for fill (e.g., behind a new bulkhead).

TABLE 2-7

SUMMARY OF DREDGING/DISPOSAL IN CONNECTICUT COASTAL AREAS UNDER FEDERAL PERMIT (1968-1977) (CUBIC YARDS x 1,000)

CONNEC-TICUT COASTAL AREA	YEARS AND PERMITTED VOLUME											
	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	TOTALS[a]	ANNUAL AVERAGE 1968-77
Western	20.1	98.2	232.1	55.5	76.3	28.0	4.8	52.1	14.5	81.9	663.4	66.0
Central	43.2	488.6	581.4	98.8	96.2	570.7	142.2	46.0	75.9	115.1	2,258.1	226.0
Eastern	22.0	65.7	490.0	2.5	115.0	23.0	2,882.0 (2.0)[b]	67.6	23.0	285.8	3,976.5 (1,096.5)[b]	398.0 (110.0)[b]
Totals[a]	85.3	652.5	1,303.5	156.8	287.5	621.7	3,029.0 (149.0)[b]	165.7	113.4	482.8	6,898.0 (4,018.0)[b]	690.0 (402.0)[b]

[a]Totals have been rounded off.

[b]Excluding 1974 New London improvement project by U.S. Navy (2,880,000 cubic yards).

TABLE 2-8

PROJECTED NON-CORPS DREDGING, 1985 TO 2035

COASTAL AREA	TOTAL VOLUME	PERCENT
Western	3,300,000	16
Central	11,300,000	56
Eastern	5,500,000	28
Totals	20,100,000	100

TABLE 2-9

DISPOSAL METHODS FOR DREDGING IN CONNECTICUT COASTAL AREAS UNDER FEDERAL PERMIT (1968-1977)

CONNECTICUT COASTAL AREA	TOTAL VOLUME 1968-1977[a]	DISPOSAL METHOD AND PERCENT OF TOTAL			
		LAND	%	OPEN WATER	%
Western	663.4	209.0	32	454.4	68
Central	2,258.1	1,630.6	72	627.5	28
Eastern[b]	1,096.5	419.5	38	677.0	62
Totals[c]	4,018.0	2,259.1	56	1,758.9	44

[a]Volumes are in thousand cubic yards.

[b]Excluding 1974 New London improvement project by U.S. Navy (2,880,000 CY).

[c]Totals have been rounded off.

SECTION THREE: PRELIMINARY CONTAINMENT DESIGN AND COST ANALYSIS

Preliminary designs and costs have been developed for two types of containment structures: (1) a simple rock dike; and (2) a circular-cell, sheet pile cofferdam. The following design cases are examined in this section:

1. A single facility to receive all dredged material projected for Connecticut from 1985 to 2035.

2. One facility in each of the three coastal areas of Connecticut to receive all dredged material projected for each area from 1985 to 2035.

The facility designs are based on siting as shoreline extensions, nearshore islands, and offshore islands. Average water depths in each siting zone and final site elevations based on structural design criteria are assumed in sizing the facilities. A present worth comparison of four options for providing the required 50-year disposal capacity is also presented. Finally, the problem of building on land created from fine-grained, organic material is addressed.

Design Volume

In order to evaluate, even in a preliminary way, potential containment facility designs, an assessment of the

volume actually occupied by the material to be dredged and disposed must first be made. Then, the required containment volume and, given a fill depth, acreage can be computed. A prediction of the degree of densification that the dredged material will undergo after placement in the containment area is needed. The empirical nature of existing sizing methods and the complex geotechnical aspects--specific gravity of solids, Atterberg limits, grain size, water content, void ratio, rate of sedimentation, etc.--of channel sediment (before dredging) and dredged material (after dredging) render reliable assessment of performance of a containment area very difficult.[3]

The commonly used method of estimating the required volume capacity is to multiply the in situ (before dredging) sediment volume by a factor determined from experience with different types of sediments in various locations. This bulking factor is a ratio of the volume of the dredged material after sedimentation in the containment area to the volume of the in situ sediment. Bulking factors ranging from 0.5 to 2.3 have been reported,[4] depending on sediment type, location, estimates of overdredging and sedimentation, and in situ sediment density. A summary of the sizing methods used by selected Corps of Engineers Offices is given in Table 3-1.

In the dredging-disposal operation, hydraulically dredged material is initially in a slurry with about 85 percent water by volume.[5] Bulking factors that take into account only the swelling of bottom sediments during dredging typically range from about 1.15 to 2.0. After disposal in a containment area, the material consolidates under its own

TABLE 3-1

SUMMARY OF SIZING METHODS USED BY SELECTED CORPS OF ENGINEERS DISTRICT OFFICES[a]

SOURCE OF INFORMATION	CONTAINMENT SIZING FACTOR TO INCLUDE[b]	MATERIAL TYPE	SIZING FACTOR[c]	COMMENTS
Buffalo District	1, 5, 6, 7	Sand Clay and silt	1.0 0.5-1.0	Uncertainty on volume dredged; observed sizing factor in Cleveland, Ohio, for organic silts: 0.79
Norfolk District	1, 2, 7	Sand Clay and silt	1.0 2.0	Factors generally overpredict required containment size
Mobile District	1, 2, 3	All types	1.2	Conservative method (long term); no losses during removal and transport assumed
Detroit District	1, 5, 6	Sand and silt	0.6-1.0	Past volume predictions both over- and under-predicted volume; 15 percent swell upon bottom removal; 50 to 85 percent reduction in volume
New England Division	1	All types	1.25	
Seattle District	1, 7	Sand Silt Clay	1.1 1.3 1.5	Sizing factors based on field observations; use weighted average sizing factor
Philadelphia District	1, 5, 6, 7	Sand Silt Clay	0.56 0.73 1.0-1.12	Factors without settlement allowances are 1.0, 1.3, and 1.8-2.0 for sand, silt, clay; settlement estimates based on field observations and column sedimentation tests
Galveston District	1, 5, 7	Silt Clay	1.35 1.65	1 year after disposal, consider that settlements have reduced volume by approximately 50 percent; method does not apply to sand
Jacksonville District	1, 7	Sand Clay	1.2-1.3 2.0	

[a]S.E. Lacasse, T.W. Lambe, and W.A. Marr, "Sizing of Containment Areas for Dredged Material," Technical Report D-77-21, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi, October 1977.

[b]1 = volume of *in situ* channel sediment; 2 = overdredging; 3 = transport efficiency; 4 = containment area losses; 5 = consolidation of dredged material in containment area; 6 = containment area foundation settlement; 7 = description of material.

[c]Sizing factor = the ratio of volume of dredged material in containment area to volume of *in situ* channel sediment.

weight, resulting in an increase in solids concentration and more storage volume. Bulking factors that consider settlement generally range from about 0.5 to 1.0. Sole consideration of the swell of dredged material cannot adequately estimate the volume in the containment area except for volume immediately following the disposal phase.

The *in situ* sediment volumes projected for the Connecticut coast from all dredging activities during the 1985 to 2035 period are summarized in Table 3-2. For preliminary

TABLE 3-2

TOTAL DREDGED MATERIAL PROJECTION, 1985 TO 2035[a]

COASTAL AREA	FEDERAL DREDGING	NON-CORPS DREDGING	TOTALS	PERCENT
Western	8.4	3.3	11.7	20
Central	24.8	11.3	36.1	61
Eastern	5.6	3.5	11.1	19
Totals	38.8	20.1	58.9	100

[a]Figures in MCY.

sizing of containment facilities, the study has assumed a bulking factor of 1.0, and so a maximum design volume of 59 MCY has been used. A more precise determination of the material bulking factor will be necessary during subsequent Stage 2 design. It should be noted here, however, that in

an impermeable containment facility in open water, the fine-grained sediments characteristic of most Connecticut harbors will be very slow to dewater and consolidate. To assist dewatering, special material handling techniques may be needed and the logistics of dredging/disposal tailored to such site management activities. Even then, a bulking factor in excess of 1.0 is likely, suggesting that a design volume of 59 MCY is perhaps too low. This is not the case, however, for a number of reasons.

First, in using a design volume of 59 MCY, the fact that a portion of the dredged material derived from permitted projects in each area would be disposed of on land (i.e., would not be available for disposal in a containment facility) has not been accounted for. Historically, about half of the non-Corps dredging has involved land disposal. If this trend were to continue in the future, then the containment design volume would be decreased, in this study to about 50 MCY. Second, it is entirely possible that a certain amount of open water disposal will be allowed as part of the overall dredged material management plan for LIS.[1] To the extent that this occurs, the volume to be contained will be lowered. Finally, the 59 MCY estimate is based on a a rather orderly schedule of maintenance dredging in all Connecticut harbors over the 50-year study period. It is very likely that many proposed dredging projects will be delayed for one reason or another. These factors are considered to offset the assumption of a bulking factor of unity.

Design Locations

As mentioned previously, three design locations were included as representative of the locations likely to be encountered: shoreline, nearshore, and offshore.

A shoreline extension containment concept is simply one in which the containment facility is joined or directly adjacent to the existing shoreline. For all practical purposes, shoreline extensions involve the creation of useable land to complement the prior shorefront land uses. Assuming an average depth of water of 3 feet (mean low water) and a required final fill elevation of +20.0 feet mlw, the shoreline extension depth of fill would be 23 feet. This number is useful for facility sizing in preliminary analyses, but must be refined based on site-specific data in actual design situations.

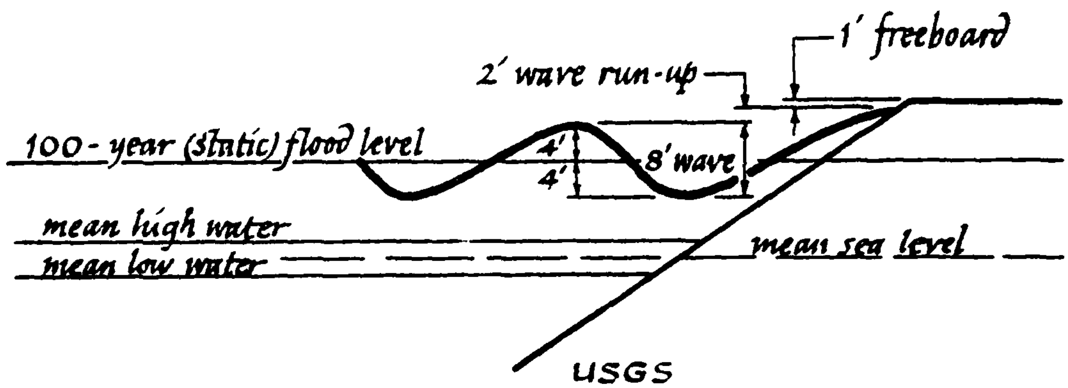
A nearshore island containment concept involves the construction of a containment facility in areas where water depths at mean low water average 12 feet. To reach a final fill elevation of +20.0 feet mlw, the depth of fill required is 32 feet.

An offshore island containment facility location is defined herein as one where water depths at mean low water average 36 feet. For a final fill elevation of +20.0 feet mlw, 56 feet of fill are required.

The safe top height of a sloped, rip-rapped structure in exposed waters where depths are generally greater than 20 feet (mean sea level) is determined by taking the static

surface of the 100-year flood level and adding to it (1) one-half the anticipated wave height, (2) wave run-up, and (3) freeboard (safety margin). The static surface of the 100-year flood level for the Connecticut shore of LIS varies from +10.0 feet msl to +12.0 feet msl depending on location.[6] Assuming a +11.0 feet msl static 100-year flood level, a wave height of 8 feet, a wave run-up of 2 feet, and a freeboard of 1 foot, the safe structure height is +18.0 msl or +20.0 mlw (Figure 3-1). This is a reasonable height for preliminary design.

Flood-plain regulations relating to the 100-year frequency tidal flood are common in coastal communities in Connecticut. These regulations are mainly a result of provisions in the 1968 Federal Housing and Urban Development Act creating a national flood insurance program. Residents in a community can obtain subsidized flood insurance under the program if the State and local community have adopted land use regulations, approved by the Federal Insurance Administration, that are intended to protect people and property in the flood plain. The 100-year flood level has become the accepted criterion for determining the area deemed appropriate for land use control. The most common control is to prohibit the construction of new facilities in the 100-year flood plain through use of zoning ordinance provisions. Therefore, if land created by the placement of dredged material is intended for some eventual productive land use, then its elevation should be above the 100-year flood level.



	MLW DATUM	USGS (NGVD) DATUM	
Height of Structure	20.0	18.0	} 1' freeboard
Wave run-up	19.0	17.0	} 2' above crest
Crest of wave	17.0	15.0	} ½ height of 8' wave
Static 100-yr. flood	13.0	11.0	
Mean High Water	4.0	2.0	
Mean Sea Level	2.0	0.0	
Mean Low Water	0.0	-2.0	

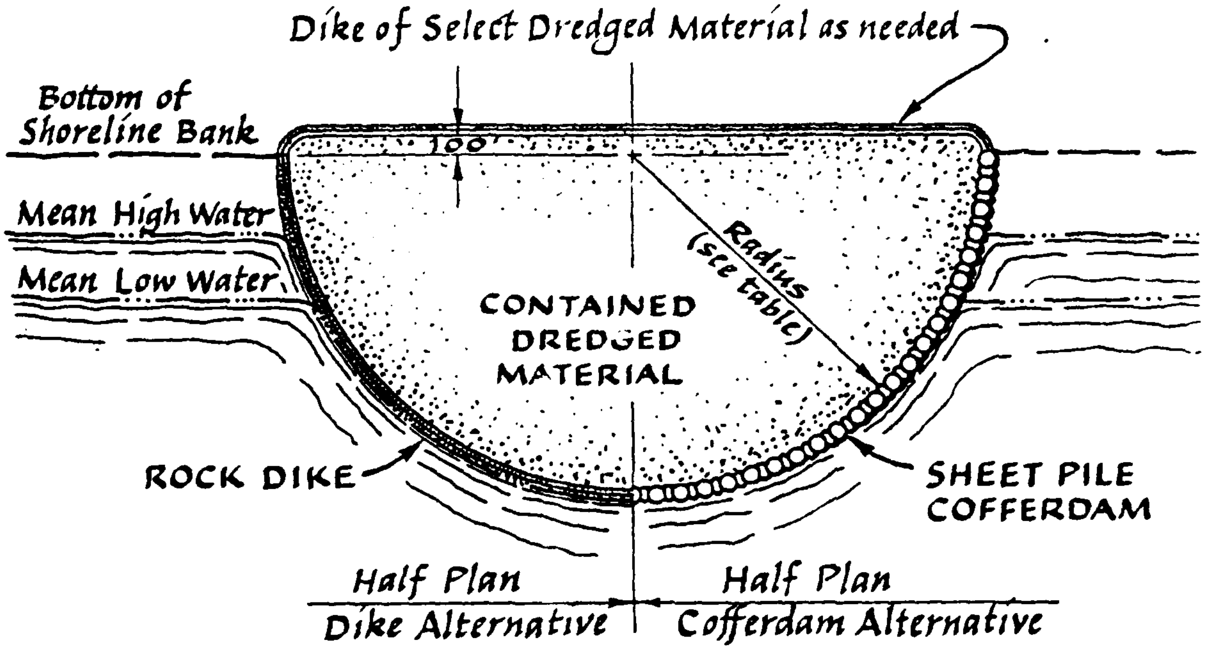
Figure 3—1. Design height computation for containment structures.

Design Configuration

A circular configuration was chosen for this study, since it represents the most economical shape, i.e., results in the least amount of structure per unit volume of dredged material retained. There is no structural advantage to the circle, such as hoop tension, since the retaining wall is a gravity structure.

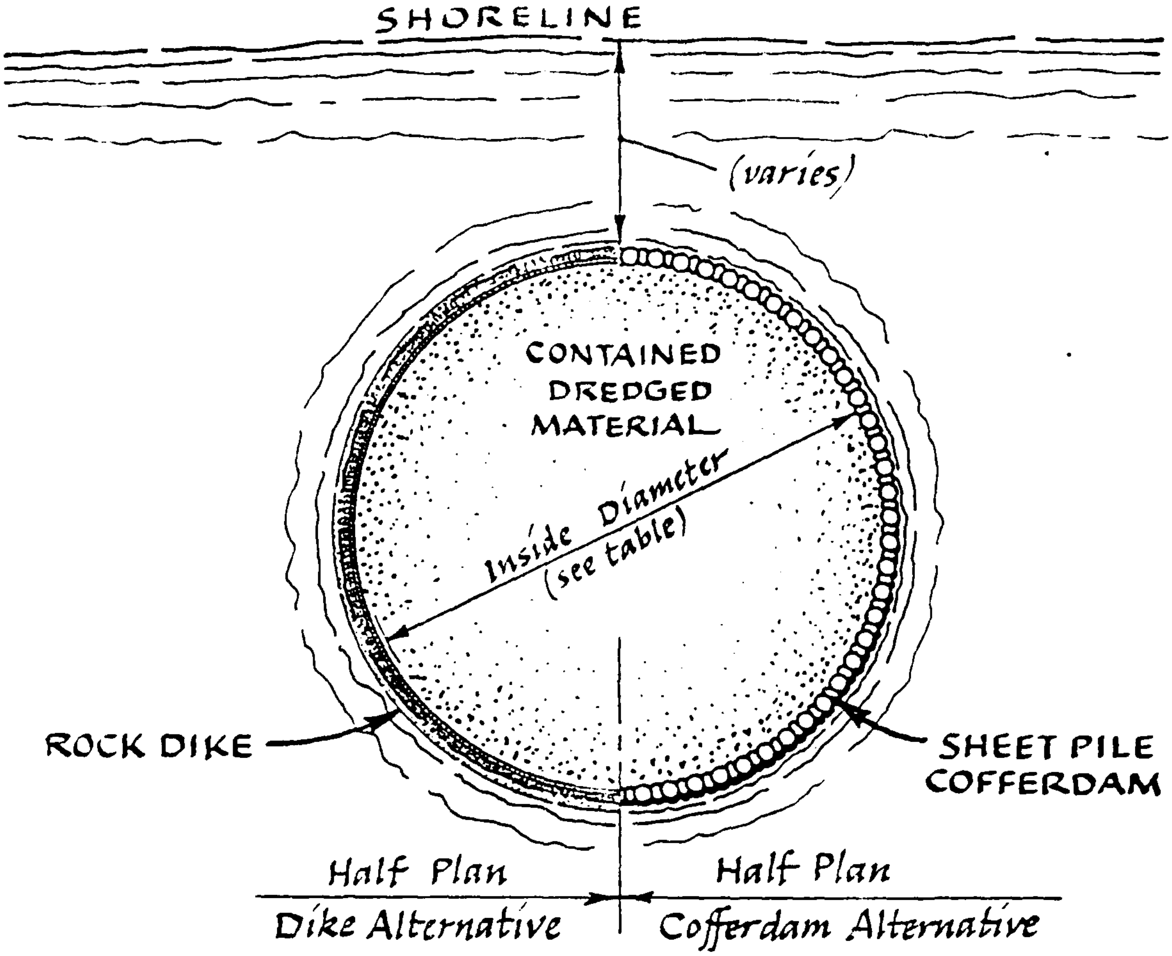
The circular shape may not always be the most advantageous shape to choose for disposal facilities, even though it is a low-cost configuration. From both aesthetic and functional viewpoints, other containment structure shapes can often be desired. For example, in a shoreline extension design, a gently curving structure resulting in a perimeter that approximates the natural contour of the shore may be preferred. Similarly, in a case where useable land is being created as a result of dredged material disposal, configuration based on the needs of the eventual site user is appropriate. New, innovative disposal facility design approaches were discussed by Mann[7] and a series of containment/land use facilities were described by Gushue and Kreutziger[8] in two recent DMRP studies for the Vicksburg Waterways Experiment Station.

For this study, the facility configurations for the three design locations are indicated in Figures 3-2 and 3-3, which also show the radius and diameter of the circular dikes for various site capacities. The capacities of interest are seen to be 12 MCY--the 50-year total volume from both the western and eastern coastal areas; 30 MCY--about half of the maximum design volume; 37 MCY--the 50-year



CAPACITY (million cubic yards)	RADIUS (feet)
12	3179
30	5045
37	5606
59	7088

Figure 3–2. Rock dike and sheet pile cofferdam shoreline configuration.



CAPACITY (million cubic yards)	INSIDE DIAMETER (feet)	
	Near shore	Off shore
12	3590	2714
30	5676	4292
37	6304	4766
59	7960	6020

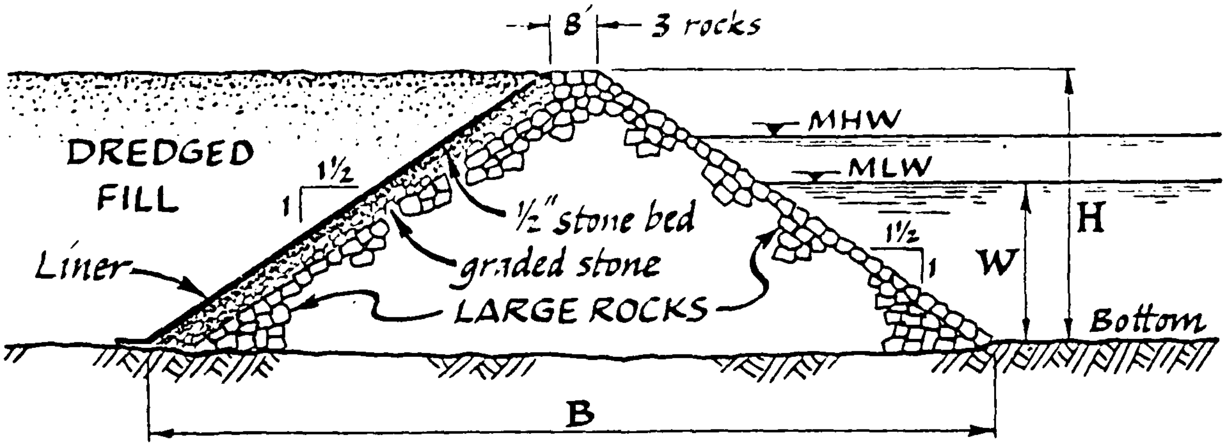
Figure 3–3. Rock dike and sheet pile cofferdam nearshore and offshore configurations.

total volume from the central coastal area; and 59 MCY--the maximum design volume. Figure 3-4 presents cross sections for the rock dike and sheet pile dike options, with dimensions indicated for each of the three alternative design locations.

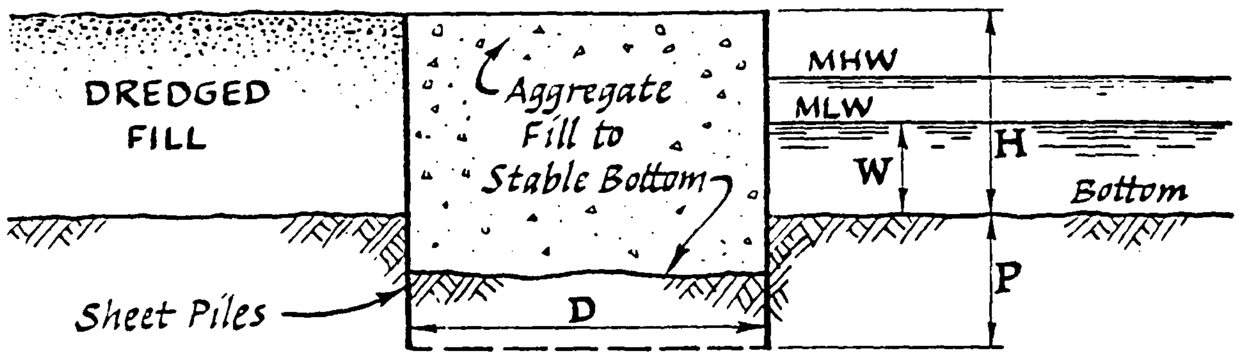
Sediment Structural Quality

Material dredged from Connecticut harbors is likely to contain relatively high percentages of fine-grained silts and clays. Corps of Engineer sediment data from samples taken in 21 Connecticut harbors was used in this study to estimate the structural capabilities of the material to be contained. The Corps data base includes a visual classification of the samples according to the Unified Soil Classification System (USCS) shown in Table 3-3. Bartos[9] has shown how the suitability of soils as foundation material can be determined in a general way from their USCS group.

For the most part, fine-grained soils exhibit poor to very poor foundation properties. In the USCS listing, this encompasses soils classified as OH, CH, MH, OL, CL and ML. Coarse-grained soils provide better foundation material, although USCS groups SC and SM, containing appreciable amounts of fines, may still be relatively poor foundation soils. This is especially true when soil density is low, as is likely to be the case in the containment facilities contemplated herein. Soils classified as SP, SW, GC, GM, GP, and GW are good foundation materials.



Cross Section of Rock Dike



Cross Section of Sheet Pile Cofferdam

Dimension	Shoreline	Nearshore	Offshore
H	23′	32′	56′
W	3′	12′	32′
B	77′	104′	176′
D	54′	78′	138′
P	15′	32′	40′

Figure 3–4. Rock dike and sheet pile cofferdam cross sections.

TABLE 3-3

UNIFIED SOIL CLASSIFICATION SYSTEM

UNIFIED SOIL CLASSIFICATION
(Including Identification and Description)

Major Divisions			Group Symbols	Typical Names
1	2		3	4
Coarse-grained Soils More than half of material is larger than No. 200 sieve size.	Gravels More than half of coarse fraction is larger than No. 4 sieve size.	Clean Gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly graded gravels or gravel-sand mixtures, little or no fines.
		Gravels with Fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixture
			GC	Clayey gravels, gravel-sand-clay mixtures.
	Sands More than half of coarse fraction is smaller than No. 4 sieve size. (For visual classification, the 1/4-in. size may be used as equivalent to the No. 4 sieve size)	Clean Sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly graded sands or gravelly sands, little or no fines.
		Sands with Fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
The No. 200 sieve size is about the smallest particle visible to the naked eye.				
Fine-grained Soils More than half of material is smaller than No. 200 sieve size.	Silts and Clays Liquid limit is less than 50		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
			OL	Organic silts and organic silty clays of low plasticity.
	Silts and Clays Liquid limit is greater than 50		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
			CH	Inorganic clays of high plasticity, fat clays.
			OH	Organic clays of medium to high plasticity, organic silts.
Highly Organic Soils			Pt	Peat and other highly organic soils.

The visual classifications found in the Corps data base are summarized in Table 3-4. Of the 218 samples classified, about 85 percent fall into the poor to very poor categories in terms of foundation properties. If the poorly graded sands group, SP, is considered a poor foundation material, which it is at low densities, then only the 2 samples classified in the GM group can be considered suitable foundation material. Overall, it is likely that sediments from Connecticut harbors will be virtually useless for supporting anything except light vegetation. A containment facility operating program to continuously dewater and densify the material could be designed to improve the structural quality of material in the case of shoreline extensions, but the degree of improvement possible is unknown at this time. In an island-like containment facility, a dewatering program will be impractical.

The poor structural quality of the material extends to the improvement dredging volumes. Recall that 11.45 MCY of new work dredging is planned by the NED, of which 7.2 MCY is in New Haven Harbor. In 1977 a soil exploration study was conducted by the Corps to determine the characteristics of the material to be dredged from New Haven Harbor and to evaluate its suitability for use in landfills. It was concluded that only about 1.2 MCY would be sandy material suitable for landfill. Based on a limited number of borings, the material was said to consist of soft, black, organic silt, in some reaches overlaying silty fine and medium sand. The sandy fractions were not considered suitable for beach nourishment.

TABLE 3-4

SUMMARY OF VISUAL CLASSIFICATIONS IN NED SEDIMENT DATA BASE

	NUMBER OF SAMPLES IN EACH USCS GROUP								
	OH	SM	SP	MH	OL	ML	GM	SC	TOTALS
Black Rock and Cedar Creek	6	1							7
Branford Harbor	15				2				17
Bridgeport Harbor	24	4	1						29
Clinton Harbor	1	2	4						7
Essex Shoal	2	1	3						6
Fivemile River	1			8					9
Greenwich Harbor	9								9
Guilford Harbor	4	2	1						7
Mianus River	4	1							5
Milford Harbor	7	2	3						12
New Haven Harbor	4		1						5
Niantic Bay and Harbor	1	4	4						9
Norwalk Harbor	13	3							16
Old Saybrook	9	4	6		2	2			23
Patchogue River	3	1							4
Saybrook Shoals	4		2						6
Southport Harbor	2		3						5
Stamford Harbor	12	1					2	1	16
Stony Creek	2				1				3
Thames River	9	4	1						14
Westcott Cove	2	3	4						9
Totals	134	33	33	8	5	2	2	1	218

Containment Structure Alternatives

The basic assumptions used in selecting containment structure alternatives were that: (1) the dredged material will be of no structural value; (2) the dredged material will undergo very little consolidation within the containment facility; (3) the dredged material will remain in the wet condition within the facility (this is the worst condition, and must be the basis for assigning lateral pressures against the walls of the containment structure); (4) the bottom of LIS is predominantly silt and sand overlaying progressively stiffer clays[10] with a bearing capacity of 2.5 tons per square foot;[11] and (5) bedrock stratum is negligible. These unfavorable conditions immediately eliminate most types of structure alternatives, including:

1. Sheet piles with tie-backs and any other system dependent upon the fill material for support.

2. Cantilever walls of any type due to the poor structural support of the subsoil and the high soil bearing pressure that would be generated.

3. Dikes using dredged material as core material.

4. Low dikes with wall extensions due to the high soil bearing pressures that would be generated.

The viable options from a structural standpoint are a simple, rock dike and a cellular cofferdam. For the latter, sheet pile cells filled with free draining aggregate will

result in the lowest soil bearing pressures, and circular cells were chosen as the most economical.

Appendix D is a technical appendix in containing all the design and cost calculations performed for the rock dike and sheet pile cell structures. The reader is urged to review Appendix D at this time. A few general comments on each alternative are made below.

Sheet Pile Cofferdam

Sheet piling is now only supplied by United States Steel, Bethlehem Steel having dropped the line.[12] The steel must conform to ASTM A 690, which has three times greater resistance to salt water splash.[13] The exterior faces of the sheets of the cells would be coated from the top to the mud line with a coal tar epoxy. The inside of the cells and the inside face of the containment wall would not need coating because of the lack of oxygen and splash action. This system results in an anticipated life of 25 to 30 years. There is no salvage at the end of the period and the entire structure would require replacement.[14] Stiffer bottom soils than assumed in LIS would allow the piles to be embedded to a lesser degree than was assumed in this analysis. Piles are furnished in 60-foot maximum lengths, but splicing is not a problem since the loads are radial.[14] The sheet pile structure in the offshore location would require a better soil bottom than assumed in LIS to achieve the design height of +20.0 mlw.

Rock Dikes

Dikes built of large rocks, bottom-dumped, result in the simplest structure available. A side-slope of 1:1.5 was assumed as being the most likely slope consistent with this operation. This results in a stable and free draining structure with reasonable soil bearing pressures. The inside face of the dike requires an impermeable (or nearly impermeable) liner to prevent the dredged material from migrating through the very porous dike. Many choices are available from various manufacturers, and depending on the material used, should have an indefinite life. The inside face of the dike will need a layer of stones graded from the large rocks of the dike to stones of about 1/2-inch to protect the liner from puncture.

Soft bottom silt would need to be removed before constructing the rock dike or the sheet pile cofferdam because soft silt would result in settlement during the life of the structure. Since the cost for this removal would be approximately the same for a rock dike or a sheet pile cofferdam, it is dropped from the cost comparisons which follow.

Container Cost Comparisons

Preliminary container wall designs found in Appendix D were developed to price the rock dike and sheet pile cofferdam on a per linear foot of wall basis, for each of the three design locations. The results are given in Table 3-5. The costs shown are construction costs and include material

TABLE 3-5

FIRST COST PER LINEAR FOOT OF WALL[a]

	SHORELINE EXTENSION	NEARSHORE ISLAND	OFFSHORE ISLAND
Rock dike	$1,100	$2,400	$6,900
Sheet pile cofferdam	$3,200	$4,700	$8,300

and installation costs. Design fees and contingencies are not included, but are estimated to be approximately 25 to 35 percent of the total construction costs estimated herein. Examples of items not included in the cost estimates are site investigation, borings, design, and construction documents. Prices used in the analysis are as follows:

1. Piles (ASTM A 690)
   - Material - $0.30 per lb
   - Installed - $0.60 per lb[14]

2. Pile coating - $1.00 per square foot[14]

3. Aggregate cell fill
   - Material - $5.00 per cubic yard
   - Installed - $10.00 per cubic yard[16]

4. Rock, bottom dumped
   - Nearshore - $25.00 per ton
   - Offshore - $30.00 per ton[14]

5. Liner - $12.00 per square foot installed[15]

Looking at Table 3-5, the rock dike is seen to be the least cost alternative in all design locations, but by substantial margins in the shoreline and nearshore cases. In the offshore case, the sheet pile structure is estimated to be 20 percent more expensive, the difference being $1,400 per foot of wall.

A comparison of the total first cost estimates of the two alternatives is presented in Figure 3-5. In view of the cost differential and the fact that the sheet pile structure would have to be replaced every 25 to 30 years, the sheet pile alternative is dropped from further cost comparison.

An important advantage of the sheet pile alternative should be noted here. Due to its vertical cross section, a sheet pile structure would enable shipping to dock alongside the containment facility. In cases involving ultimate site development for a water-dependent land use, the extra premium associated with a sheet pile structure may well be worth it. It would certainly be feasible to incorporate sheet pile segments into a rock dike in order to provide ship access or to conserve water space near a channel.

In addition to being the most economical design, the rock dike offers the advantages of indefinite life, favorable appearance, ease of construction, minimal maintenance, and a rough, sloping surface that provides attractive habitat for marine life.

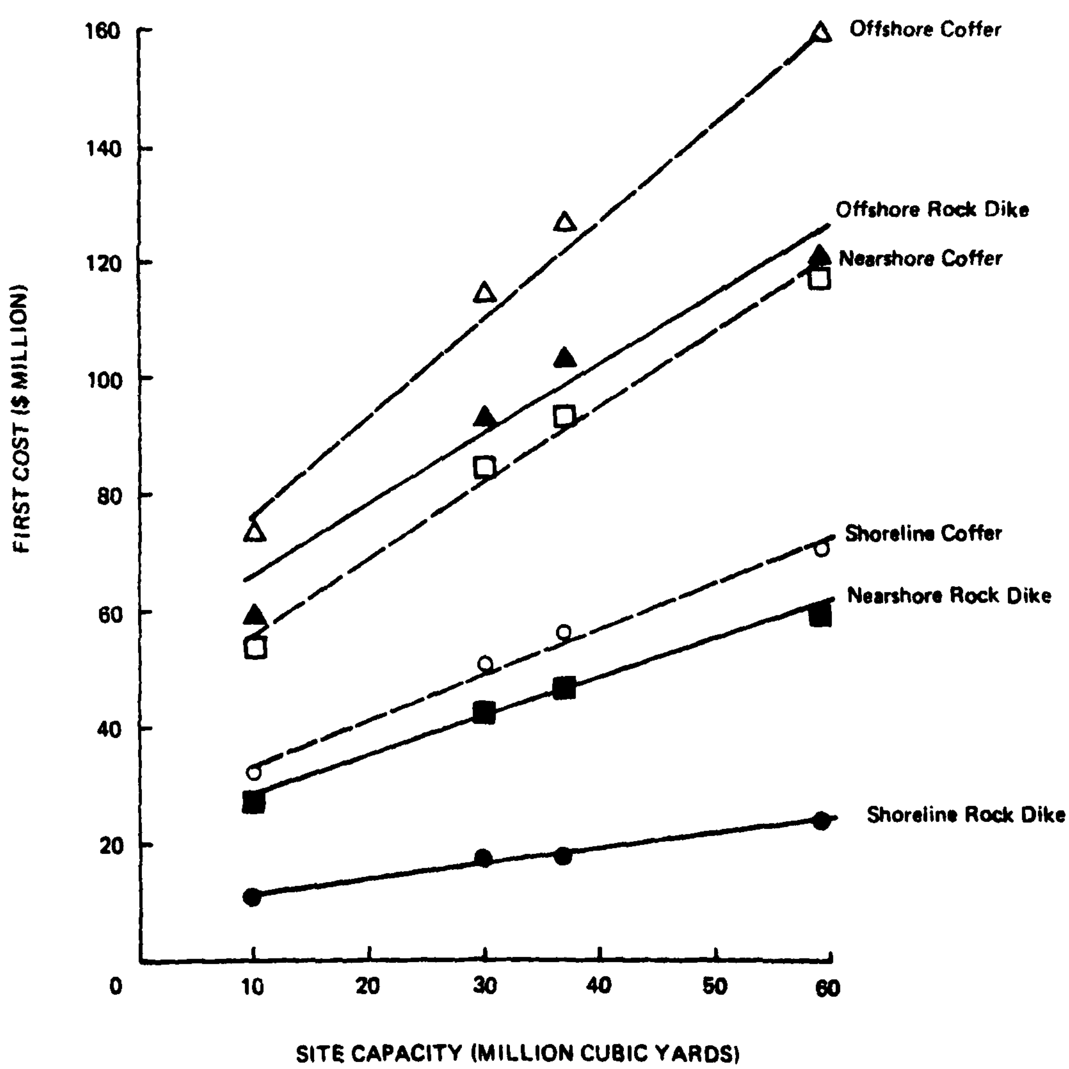


Figure 3–5. Total first cost estimates of rock dike and sheet pile coffer dam.

Present Worth Analysis of Rock Dike Alternatives

To illustrate the range of possible solutions, consider the following four alternative schemes for providing 50 years of containment capacity for Connecticut harbors:

1. A single 59 MCY facility constructed in the central coastal area in year 1 of the 50-year period.

2. Two 30 MCY facilities, one built in 1985, the other 25 years later in 2010.

3. Three containers, one in each coastal area, built in 1985 to satisfy the 50-year containment requirements in each coastal area (say 12 MCY in western and eastern areas, 37 MCY in central area).

4. Three 12 MCY containers, one in each coastal area, built in 1985. In the western and eastern areas, this satisfies the 50-year requirement. In the central area, another 12 MCY facility would be built in 2002 and a third 12 MCY facility in 2019.

The present worth of these four alternatives is compared in Table 3-6, using an interest rate of 6-7/8 percent. While the value of one alternative relative to another might be influenced by effects of inflation, it is impractical to project by extrapolation the effects of inflation. Therefore, the economic merits of the alternatives have been evaluated by using present value comparisons based on absolute 1978 dollars. This approach provides a reasonable

TABLE 3-6

PRESENT WORTH OF ROCK DIKE ALTERNATIVES FOR PROVIDING 50-YEAR CAPACITY

ALTERNATIVES	DESIGN LOCATION	PRESENT WORTH ($ million)
1. 59 MCY facility now	shoreline	24.5
	nearshore	60.2
	offshore	131.5
2. 30 MCY facility now, another in 25 years	shoreline	20.9
	nearshore	51.3
	offshore	112.2
3. 12 MCY facility now in both west and east, 37 MCY facility now in central	shoreline	41.4
	nearshore	102.3
	offshore	224.0
4. 3-12 MCY facilities now, another 12 MCY in central area in 17 years, and a third 12 MCY in 34 years	shoreline	37.8
	nearshore	93.8
	offshore	205.4

[a]See Appendix D, pages D-16 and D-17 for present worth calculations.

comparative analysis of alternatives where investment occurs at different points in time.

As expected, the shoreline location is the most economical in all cases, and the more capacity that is provided now, the higher the present worth of the alternative. Although more accessible, the smaller capacity, regionally sited facilities are more expensive than the centrally sited, higher capacity facilities. Of course, a final decision

among containment schemes such as those compared above would be based on many factors in addition to cost.

It is interesting to consider the areal extent of the containment facility under various design location and capacity conditions. The size of the rock dike container is indicated in Table 3-7. Note that to provide offshore containment of 50 years worth of dredged material from all Connecticut harbors, about 680 acres of LIS bottom would be lost. At present, over 2,500 acres of LIS bottom are designated as available for dredged material disposal under the joint New York/Connecticut Interim Plan.[1] Considering the three areas designated under the latest revised Interim Plan, about 2,560 acres of LIS bottom are affected by open water disposal. Over 1,900 acres are in water 70 to 80 feet deep, while the balance is in water over 150 feet deep.

Building Upon Containment Facilities

As indicated previously, it is felt herein that islands created with material dredged from Connecticut harbors will be incapable of providing any significant structural support. Even the most passive land uses would require a 3- to 4-foot base of material for planting trees, etc. and the unconsolidated, wet dredged material will not have the needed bearing strength. In view of this, and given the limitations in foundation designs currently used, two foundation options are available to enable ultimate facility development (see Figures 3-6 and 3-7):

TABLE 3-7

ROCK DIKE CONTAINER DIMENSIONS AND AREAL EXTENT[a]

	CAPACITY (MCY)											
	12			30			37			59		
LOCATION[b]	SL	NS	OS	SL	NS	OS	SL	NS	OS	SL	NS	OS
Inside diameter[c]	6,358	3,590	2,714	10,090	5,676	4,292	11,212	6,304	4,766	14,176	7,960	6,020
Area[d]	386	243	146	952	597	353	1,171	735	433	1,860	1,166	683
Perimeter[c]	10,020	11,366	8,671	15,883	17,920	13,628	17,645	19,893	15,117	22,301	25,095	19,057

[a]More complete design data are provided in Appendix D.
[b]SL-shoreline extension; NS - nearshore island; OS - offshore island.
[c]Feet.
[d]Acres.

Section—Floating Foundation

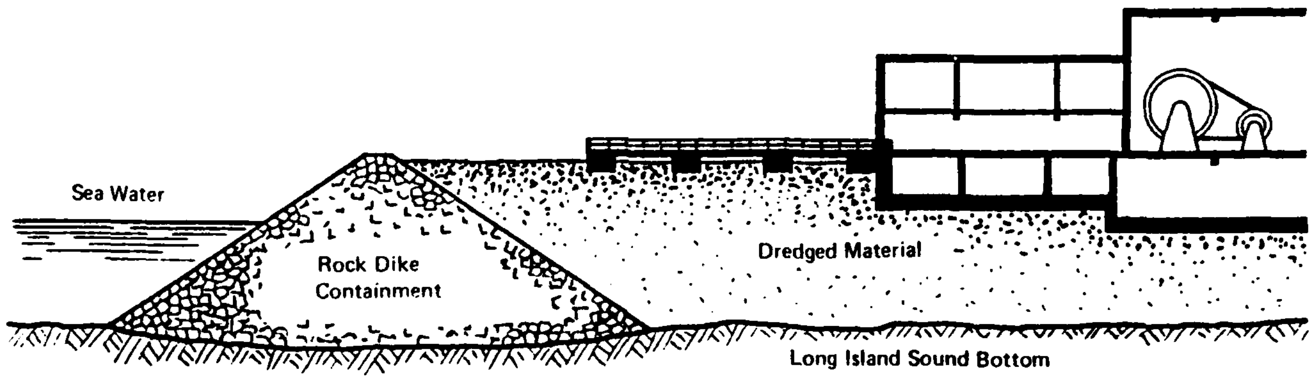


Figure 3–6. Floating foundation alternative.

Section—Pile Foundation

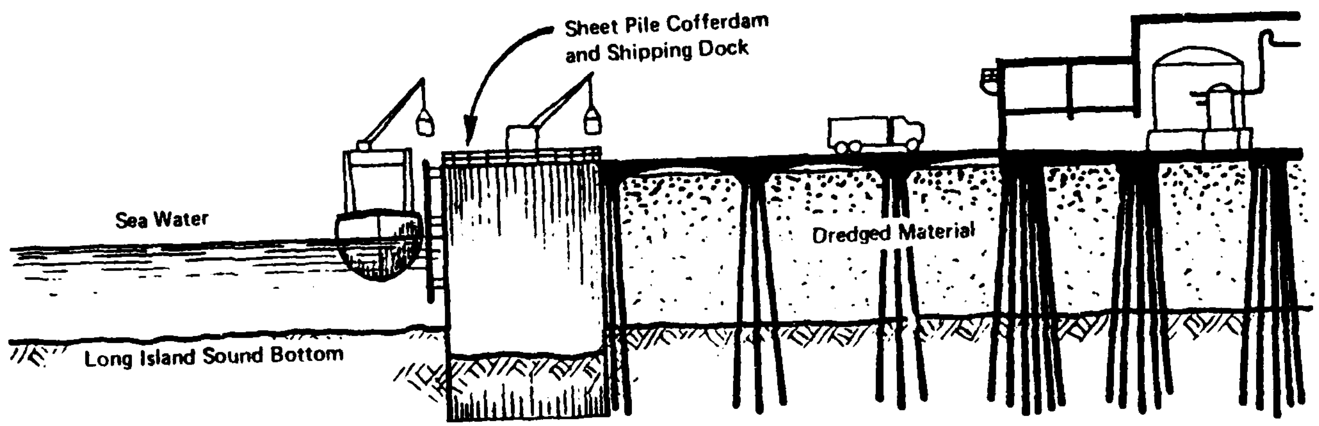


Figure 3–7. Pile foundation alternative.

1. Floating foundations.

2. Pile foundations.

Floating foundations derive their support from the displacement of the underlying material, exactly as a boat does in water. Structures of almost any size could be supported on the dredged material by floating foundation. Significant settlement would be certain; but such settlement should be uniform, and if adequately recognized during design, should present no barrier to proposed uses. Everything would need to be floated, including roadways and walkways. Some of these could be incorporated into the building design, and if the roadways and walkways were made relatively massive in relation to the loads passing upon them, displacements would not be objectionable. The use of floating foundations is not exotic or new, but would be very costly. Where the possibility of using piles is available, piles will generally prove to be more economical.

For pile foundations, piles are driven either onto bedrock or into soil with sufficient strength to hold the design load. A review of the Long Island Sound geology reveals no reason to assume that piles could not be an economical method of foundation.[10] Piles offer a settlement-free, stable way of supporting any type of structure, the only limiting factors being the bearing capacity of underlying soil and the economics of pile-driving deep enough to reach it.

Dredged material islands offer an attractive site for building for several reasons. They incorporate a shipping dock without crowding existing harbors; they provide a

virtually maintenance-free rock face against the action of the sea; the site is open and uncluttered; and, perhaps most importantly, they may be located only minutes from busy coastal cities. There are no structural barriers to building on these sites, only the need to combine tried-and-true methods with innovative design and plentiful financial resources. The most feasible offshore island land uses are those that involve high economic returns to the site developer/user, particularly when foundation conditions necessitate special design and construction methods.

Dredging Transport Costs

Dredging of the harbors bordering Long Island Sound will almost certainly be done hydraulically if disposal in a containment facility is planned. The material could be pumped in a floating pipeline to the disposal area, but the upper limit for pumping is about 2 miles because it is impractical to locate booster pumps on the water. The method of transport to large containment facilities can therefore be assumed to be barge transport, followed by pumping from the barge over the dike wall into the facilities. There appears to be no practical alternative to pumping over the dike wall, considering the need to positively contain the sediments and its contaminants. The number of firms which could pump over the dike wall seems to be limited, the limiting factor being the equipment needed and government requirements to use only domestic products on government-funded work.

Dredging costs are extremely difficult to estimate due to variables in sediment consistency, depth of material dredged, distances covered, fuel costs, and quantity versus time requirements. However, for dredging transport by barge for a distance of about 30 miles, a figure in 1978 dollars of $3 to $5 per cubic yard would be reasonable. Past experience has indicated an inflation factor of about 7 percent per year. An increase in haul distance from about 15 miles to about 50 miles would result in an increase in cost of 15 to 20 percent.

It should be noted that the costs associated with the need to transport the material over longer distances are determined by the economics of a particular dredging operation. The least cost dredging operation is one in which dredge plant productivity is maximized. If a longer transport distance is imposed on a project that typically required only one scow (or barge) to receive and transport material, then, to avoid dredge plant downtime while the material is dumped, another scow and associated labor would have to be used. For long distances, three scows (one coming, one going, and one filling) may be necessary. Clearly the factors relating to dredging costs are very difficult to estimate apart from specific situations. Firm figures are really only available from bids accepted on specific jobs, and even bids on the same job can vary by as much as 40 percent. The constraints that may result from dredging cost and transport factors will require in-depth study to define in precise quantitative terms.

SECTION FOUR: PRELIMINARY SITING ANALYSIS

Assuming that containment of dredged material is found to be feasible in Connecticut, where might the containment facility(ies) be located? In this section, an attempt to select potential land creation sites for in-depth study during Stage 2 is described. This preliminary siting analysis, which was based on macro-level environmental resource and land use data, proved to be too general to support firm, precise recommendations on potential sites. However, many locations in the Sound that have been cited in the past as potential island creation sites are reviewed. For large containment facilities, shoreline and nearshore siting locations in LIS often coincide with areas of high biological value (e.g., oyster beds, finfisheries). Such significant biological conflicts may not, however, be associated with certain deeper water areas, particularly those that have been used for disposal purposes in the past.

Data Sources

The siting analysis began with the collection and review of data to be used to initially identify potential sites in the shoreline and nearshore/offshore design locations. The data collected at this preliminary stage was macro-level data, which was available from several sources, including the following:

1. NOAA nautical charts for LIS at scales 1:10,000 to 1:50,000.

2. NOAA coast charts for LIS at scale 1:80,000.

3. USGS standard topographic maps for Connecticut coastal quadrangles at scale 1:24,000.

4. Connecticut Coastal Area Management (CAM) Program resource factor maps at scale 1:24,000.

    - coastal land use (1975)

    - industrial/commercial zones along the coast

    - shellfish bed locations in all nearshore and estuarine areas

    - designated tidal wetlands in the 36 coastal towns in Connecticut

5. Connecticut Department of Agriculture oyster ground location maps at scale 1:24,000.

6. Various maps prepared as part of the Long Island Sound Regional Study by the New England River Basins Commission, available at CAM office.

    - wastewater treatment plants and service areas at scale 1:250,000

    - critical erosion areas at scale 1:62,500

- commercial finfishery at scale 1:250,000
- lobster and conch concentrations at scale 1:250,000
- shellfisheries at scale 1:250,000

7. The Atlas of Natural Resources in Long Island Sound,[10] in which data on tides, bottom sediment size, geomorphology, benthic concentrations, crab distributions, lobster distribution, shellfish beds and finfish distribution is presented on a series of 5" x 10" maps showing the entire LIS region.

8. Connecticut Office of Policy and Management proposed land use classification system map,[21] showing urban centers, urban growth areas, urban conservation areas, preserved open space, and preservation/conservation areas along the coast at scale 1:250,000.

Preliminary Siting Exercise

The above environmental and land use data were synthesized on a series of working base maps (scale 1:125,000) of LIS and the Connecticut coast. During the preliminary siting exercise, the data represented on the general base maps were supplemented where possible by more detailed data in order to identify localized natural or man-made conditions important for preliminary site identification. For example,

detailed location maps (scale 1:24,000) of oyster grounds in LIS were available for more closely examining potential sites shown on the general base maps to be in proximity to shellfish areas.

The process of identifying potential land/island creation sites began with a review of all past and present open water dumping grounds, and of the island creation sites suggested in 1974 by McAleer.[18] In conjunction with the working base maps, this provided a general indication of areas where a containment facility would conflict with current land and water uses. The search for potential sites, including a critique of sites suggested by McAleer, was guided by criteria developed specifically for preliminary siting purposes. These criteria, which are described later in this section, and the professional judgements of the study team were the basis upon which preliminary siting decisions were made. It should be noted that the study team was comprised of a civil engineer, a planner, a geologist, and a marine biologist.

The biological resource data for LIS provided an overall environmental framework for initial site review, enabling fisheries, wetlands, etc. to be plotted and considered, albeit at a gross level (except where detailed data were available such as in the case of oyster grounds). Although environmental impact is only one of many siting considerations, areas of obviously high biological value were eliminated from further consideration as potential container sites. It is recognized that very detailed, site-specific environmental review of potential sites will be necessary during Stage 2 before any firm siting decisions

can be made. As Figure 4-1 illustrates, most of LIS _in toto_ is valuable marine habitat.

Another important aspect of preliminary siting was the various wind, tide, current, and wave energy regimes in the Sound (Figure 4-2). The energies are: (1) wave energy as a product of wind velocity and duration, water depth, and fetch; (2) scour by ebb and flow currents and their localized effects; and (3) littoral currents created by the angle of incidence of waves.

For wave energy in LIS, the only significant fetch waves are those that arrive from the open ocean through "the Race" between Long Island and Fishers Island. The fetch in this area is 3,000 miles or more. Waves generated within the Sound have a maximum fetch of about 10 miles. Wind rose data on wind directions and their percent frequency of occurrence are indicated on Figure 4-2. Scour is caused primarily by tidal currents and, generally, the only area of significant tidal current scour in LIS is the Race. Littoral currents produce the longshore movement of sediment, but they are inconsistent (i.e., dependent on the incidence angles of waves) and rarely have significant erosion velocity.

Wave energy effects are of concern in the engineering design of containment facilities in relation to structure configuration and orientation, reinforcement, size, and type of rip-rap, and outboard slope of the material. Areas of very high energy will require containment structures with inordinately high construction costs. This study has assumed that containment facilities would only be placed in moderate or low energy zones.

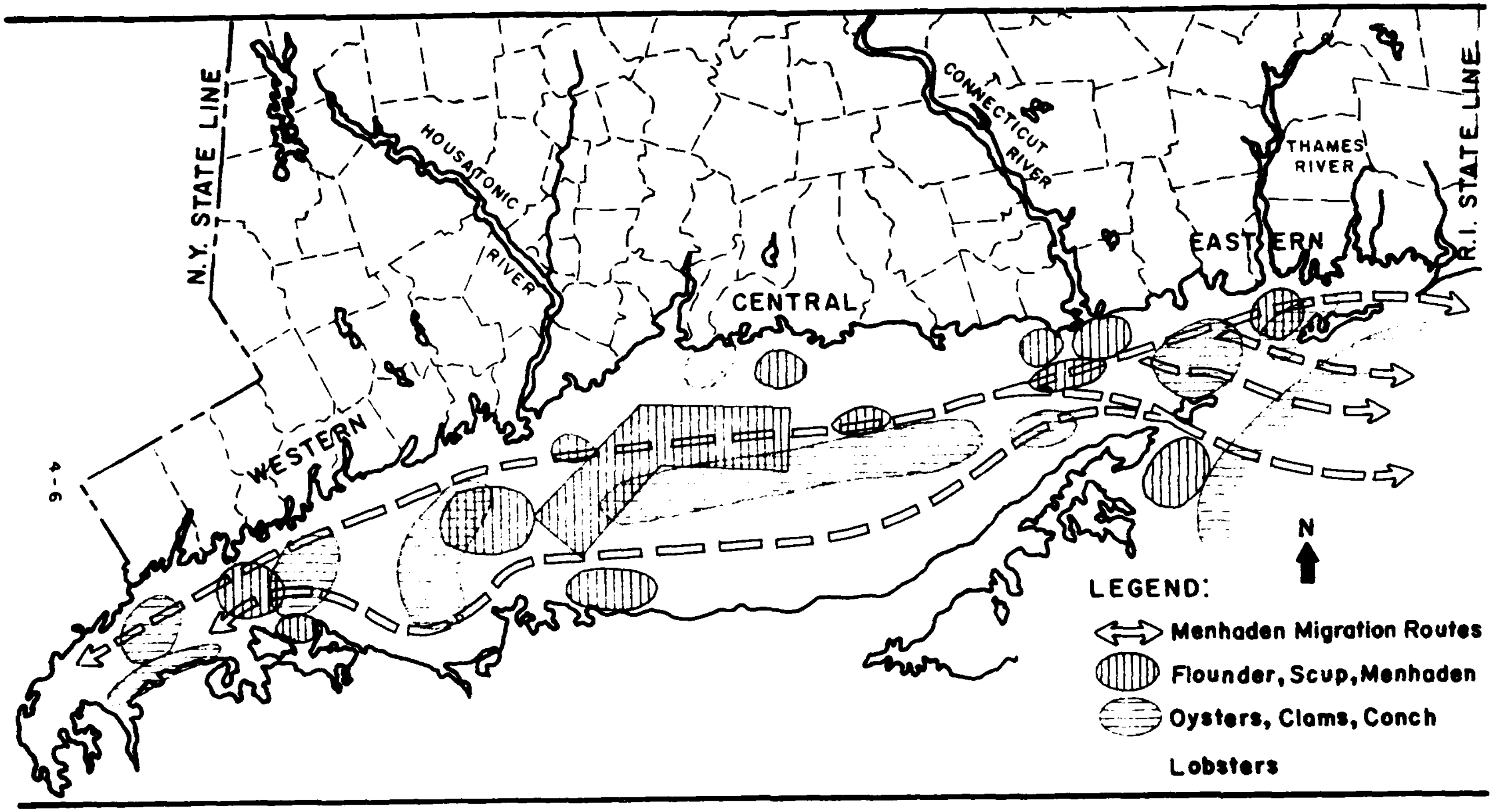


FIGURE 4-1 FINFISH, SHELLFISH and LOBSTER fisheries in Long Island Sound.

FIGURE 4-1

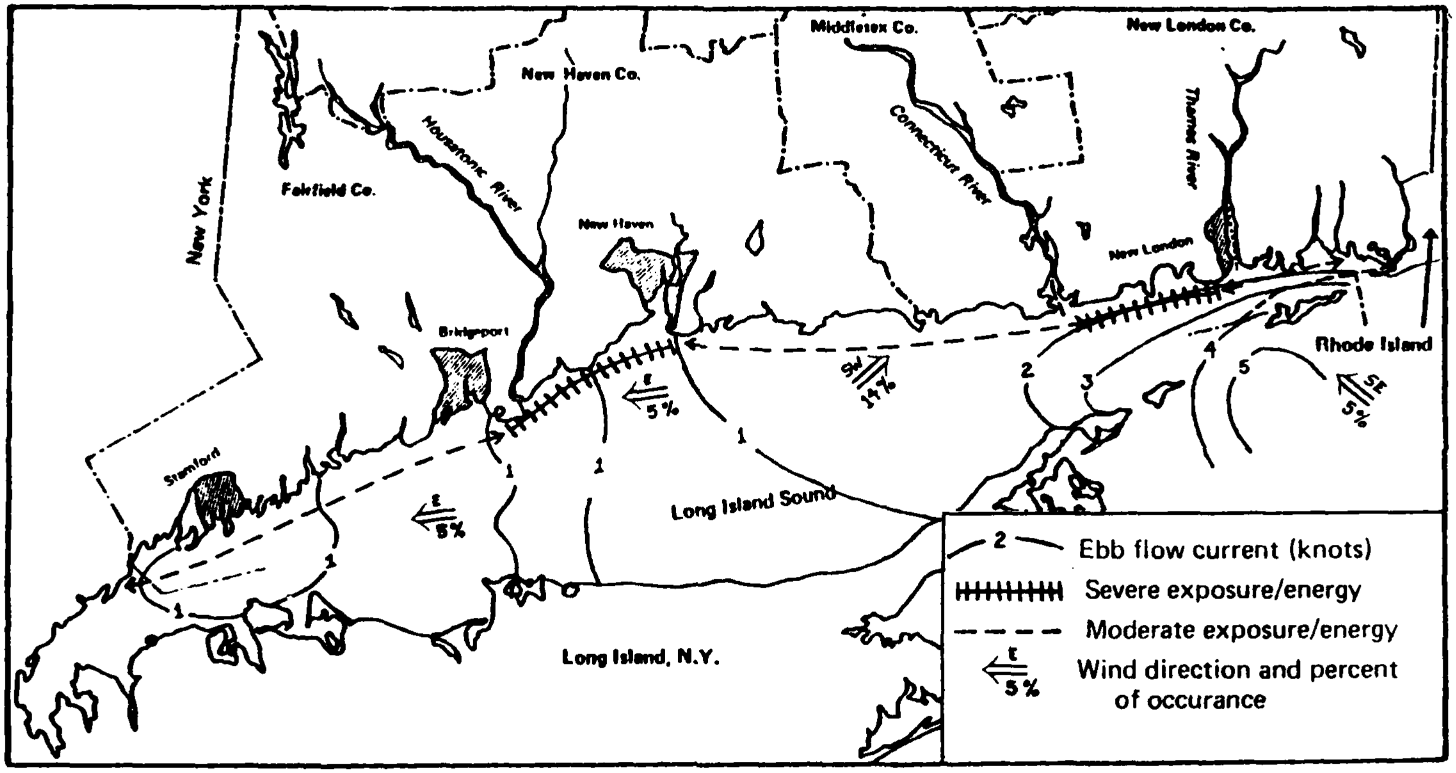


Figure 4–2. Wave/current energy regimes in Long Island Sound.

In conjunction with preliminary siting decisions based on the natural characteristics of the Sound, additional judgements were made on the basis of existing man-made characteristics of the Connecticut coastal zone as well as plans for future land uses. An initial source of information consulted to locate potential shoreline extension sites was the State of Connecticut Conservation and Development Policies Plan, Proposed Revision of 1979.[21] This plan includes a proposed land classification system indicating the patterns for development and conservation that best address, according to the Connecticut Office of Policy and Management, the multiple development needs of Connecticut. Although the land classification is not in terms of specific future land uses, such as in a land use or zoning plan, it does identify areas of suitability and opportunity for application of the conservation and development policies to secure the most beneficial and economical long-term results from State government actions. Nine land categories are contained in the plan, including four types of urban areas, three types of environmental concern areas, and two types of rural areas. During preliminary site identification, two of the urban categories--urban centers and urban growth areas--were used to initially locate potential shoreline extension opportunities using dredged material. Conversely, environmental concern areas were excluded from further consideration.

The results of the preliminary siting exercise are just that--preliminary. The potential containment facility locations identified below are offered as a base from which a more rigorous site selection process during Stage 2 can begin. It should be recognized that the site review undertaken in this study was geared to large-volume, long-life

facilities. Small-volume, localized siting opportunities were not examined in this study, but will be examined in detail during the Stage 2 siting process.

In searching for potential sites, separate site review criteria were established for the shoreline and nearshore/ offshore design locations. These criteria are described below along with the potential sites.

<u>Shoreline Criteria and Site Review</u>

The basic site identification criteria in the shoreline location reflect the rationale that the coastal shorefront areas with any potential at all for containment facility siting are those that:

1. Have a man-made edge.

2. Are in industrial use, especially water-dependent.

3. Are, or have been, used for disposal of solid waste, dredged material or municipal/industrial sewage.

4. Are in proximity to urban structures, such as transportation systems, industrial land uses and markets, etc.

5. Have some prior impetus for land creation and development, such as an industrial expansion site,

or a site that could be developed to provide waterfront recreation land in an urban area.

6. Have an existing erosion-deposition or wave energy problem that could be alleviated by construction of a containment facility.

7. Are owned by either local, State, or Federal government.

Much of the coastal shoreline of Connecticut could be ruled out beforehand using just the USGS and NOAA maps and some knowledge of the coast, particularly in terms of the location of residential and recreational areas, shellfish beds, small boat navigation zones, etc. For coastal sites not immediately ruled out, more detailed site-specific information than was available in this study would be needed to support even a preliminary finding of potential as a disposal location. Nevertheless, with an "open mind," the above criteria were applied and three possible shoreline extension sites were identified:

1. Bridgeport - between west breakwater and Tongue Point in Bridgeport Harbor.

2. New Haven - tidal flat area near Long Wharf and adjacent to Connecticut Turnpike on west side of New Haven Harbor.

   - tidal flat area adjacent to East Shore Park on east side of New Haven Harbor.

At first glance, the Bridgeport site and the New Haven site near East Shore Park appear to offer potential for containment followed by ultimate development to expand existing, adjacent public recreational areas. Similarly, the New Haven Long Wharf site has features, such as vehicular and waterway access, that make it attractive as an industrial area. (Problems of dredged material quality, size of facility, etc. were not considered during initial site identification since such problems would be addressed during Stage 2.) As it turned out, on closer examination each of the above sites was determined to be in proximity to shellfish habitats considered critical by the State of Connecticut.[16] Decisions as complex as disposal facility siting should not be made solely on the basis of one factor such as biological value, but the fact that these sites are American oyster (Crassostrea virginica) seeding grounds would eliminate them from further consideration.

Another site in New Haven--a tidal flat area between the mouth of Old Field Creek and the Sandy Point breakwater--was briefly investigated by the Corps as a possible container facility location in 1973.[22] At that time it was speculated that, if a double-wall, sheet pile cell containment facility were constructed, then ". . . at some future date a 60-acre island would become available." On the basis of a preliminary cost analysis, the container alternative for New Haven was rejected in 1973, but the proposed location (an area devoid of oyster grounds) is perhaps worthy of investigation as a shoreline extension possibility during Stage 2 of the containment study.

In view of the density of development and the recreational and ecological resources along the Connecticut coast, it is concluded that the shoreline extension concept for containment of dredged material is not very promising for large-volume, long-term disposal. Small-volume, isolated opportunities were not examined in this study, but the fact that the created land would not be useable without costly site engineering (including a continuous dewatering/densification program) is a strong disencentive. Very detailed sediment analysis would be needed in order to evaluate small-volume containment for land creation, material rehandling, etc. The various areas of publicly owned coastal property shown in Figure 4-3 are considered worthy of close examination during Stage 2 as potential small-volume facility locations. It is fully understood that some or all of the coastal areas highlighted in Figure 4-3 may prove unsuitable for containment facilities due to environmental impacts, public opposition, or other factors to be evaulated during Stage 2.

Nearshore/Offshore Criteria and Site Review

The criteria developed to initially identify nearshore areas as potential containment facility sites reflect a siting approach based on finding which nearshore areas should be excluded for one reason or another. The preliminary nearshore siting review was designed to:

1. Avoid environmentally sensitive areas such as shellfish beds, lobster and conch areas, finfish

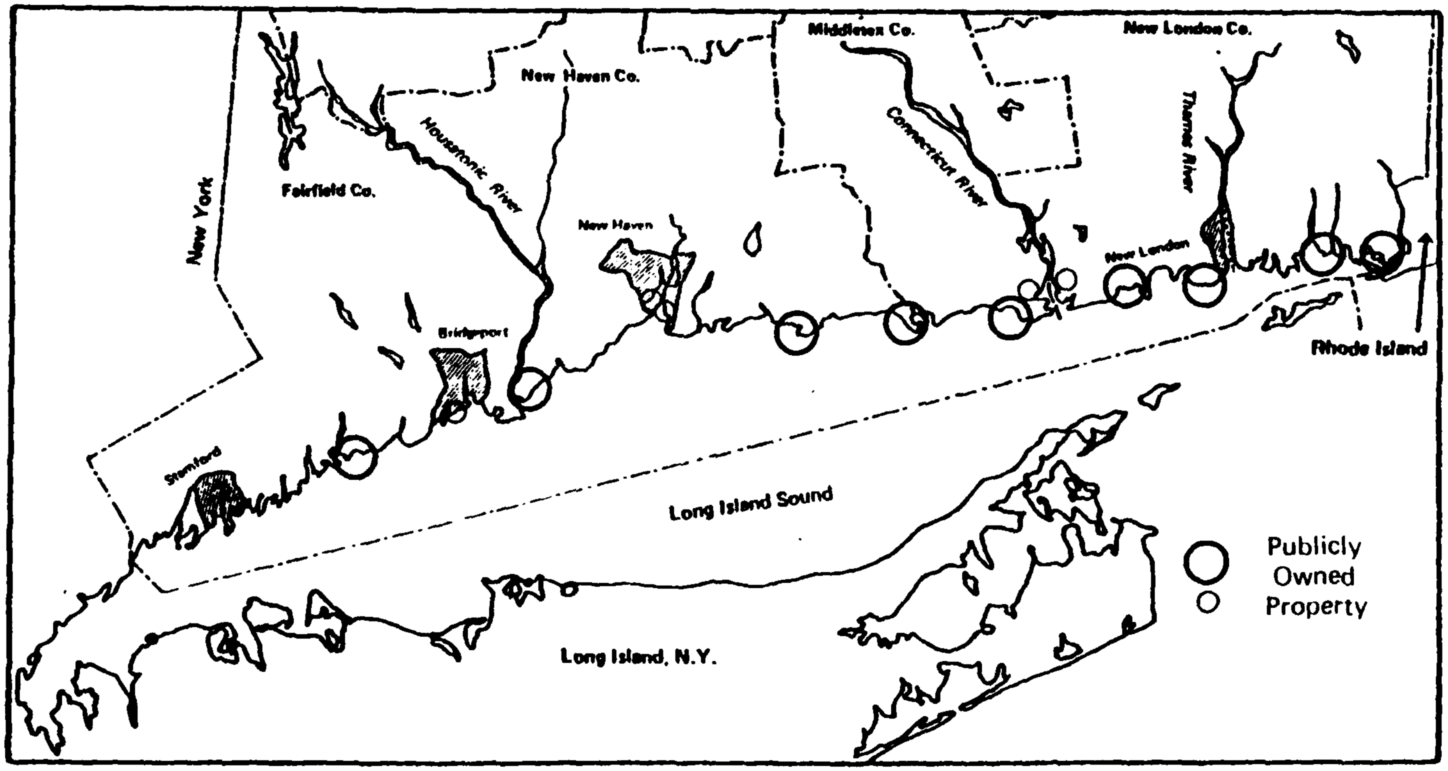


Figure 4–3. Publicly owned property along the Connecticut coast.

concentration zones and anadromous species' spawning and migration areas.

2. Avoid U.S. Navy operating areas.

3. Avoid commercial and recreational boating navigation zones, particularly in limited open water areas.

4. Avoid areas of high wave energy, principally near the eastern end of Long Island Sound.

5. Avoid locations near residential developments.

6. Avoid submerged historic wrecks, archaelogical sites, and heritage areas.

A starting point for siting in the nearshore zone was the 1974 report on artificial islands in LIS by McAleer. The McAleer report listed a number of both nearshore and offshore potential island creation sites in the Sound. The major siting criterion used by McAleer seems to have been to select known shoal areas and shallow water zones, with adjacent deep water a prerequisite for offshore sites. From an engineering viewpoint, it makes good sense to select shoals and shallow zones since construction costs increase with operating depth. However, from an ecological viewpoint, a siting exercise based on shoal and shallow areas is conceptually deficient, since shoals are often valuable resource areas.[19] The nearshore island creation sites proposed by McAleer are listed below:

1. Greenwich
   - Little Captain Island
   - area outside Calf Island

2. Stamford
   - area from breakwaters to The Cows

3. Noroton
   - three sites in 2 to 14 feet of water

4. Darien to Westport
   - Greens Ledge
   - Goose Island
   - Cockenoe Island
   - Georges Rock

5. Southport to Housatonic River
   - Rocky Pine Creek Point
   - area near Point No Point

6. Milford to New Haven
   - Milford Point
   - Charles Island
   - Welchs Point

7. New Haven to Branford (Sachem's Head)
   - eight sites 1 to 2 miles offshore with rocky bottoms, 8- to 10-foot depths

8. Branford to mouth of Connecticut River
   - seven sites 1 mile offshore in 8 to 15 feet of water

- Duck Island lighthouse and breakwater
- Falkner Island
- Long Sand Shoal

9. Connecticut River to Stonington Harbor
   - six sites 1 mile offshore in 5 to 15 feet of water
   - Hatchett Reef
   - Bartlett Reef

In addition to the nearshore sites listed by McAleer, the City of Groton Conservation Commission, in a letter to the Corps of Engineers dated 21 November 1977, suggested that an artificial island be constructed in Fishers Island Sound, just east of the entrance to the Thames River. The site was described as "presently a hazard to navigation of recreational boating and is of little value for fishing and lobstering."[20] The project team could not, using its criteria, identify any other nearshore areas with the potential for conversion into an artificial island through dredged material disposal, but a number of comments on the sites listed above are warranted.

As mentioned previously, McAleer used engineering criteria alone in choosing potential nearshore island creation sites. Given the purpose for which that siting exercise was done, the approach taken seems more than reasonable. The problem of siting for dredged material disposal, however, must consider many engineering, ecologic, economic, social, and political factors. In this study, the nearshore sites proposed by McAleer were reviewed according to general social, aesthetic, and ecological criteria, and

all of the sites were judged essentially infeasible as locations for a major disposal facility. This was accomplished with the assistance of an informal site review session attended by representatives from several Connecticut agencies and the National Marine Fisheries Service.

On an overall level, the engineering-related advantages of shoal island creation are diametrically opposed by qualitative ecological value. In the same way that the Georges Bank region in the North Atlantic is a rich, diverse, and productive habitat, so too by nature are shallow bars, shoals, rock ledges, and other shallow water phenomena in LIS. It is not an ecologic accident that rocky shoal areas are productive lobster habitats nor that shallow sand bars attract bait minnows and commercially valuable fish populations. Shallow water regions, because they intersect the photic zone, are extremely efficient primary production areas. Primary producers tax the light energy from the sun, and form the critical base for the estuarine food web. The essential ecologic character of the nearshore zone, then, is the basis for assigning low feasibility to locating a large volume containment facility in shoal and shallow water areas.

Once again, it is emphasized that ecologic (or, e.g., aesthetic) value alone should not be the sole basis for rejecting potential disposal facility sites. In a detailed Stage 2 site selection process, many environmental/economic/social tradeoffs will be necessary to choose among alternative facility locations. The nearshore locations proposed in the McAleer study were considered, by the State and Federal personnel participating in the informal review, to

have little chance for gaining approval for disposal. However, the need for site-specific project design and environmental impact data upon which to base disposal facility siting designs was stressed by all.

With respect to the offshore design location, the principal siting criterion used in this study was to find sites with water depths of 30 to 40 feet. McAleer used the same criterion to identify offshore sites, provided that adjacent deeper water areas were available to accomodate the shipping needs of potential island uses. The list of offshore sites identified in this study is given below, with those sites initially identified by McAleer in 1974 noted with an asterisk (note that all these offshore sites are State-owned and are indicated in Figure 4-4):

1. Stamford
   - three sites 1 to 2 miles offshore in 28 to 32 feet of water
   - R32A shoals*

2. Darien to Norwalk
   - one site east of Budd Reef
   - Cable and Anchor Reef*

3. Stratford
   - Stratford Shoal*

4. New Haven
   - roughly 20 square mile area in the vicinity of the historic New Haven dumping ground.

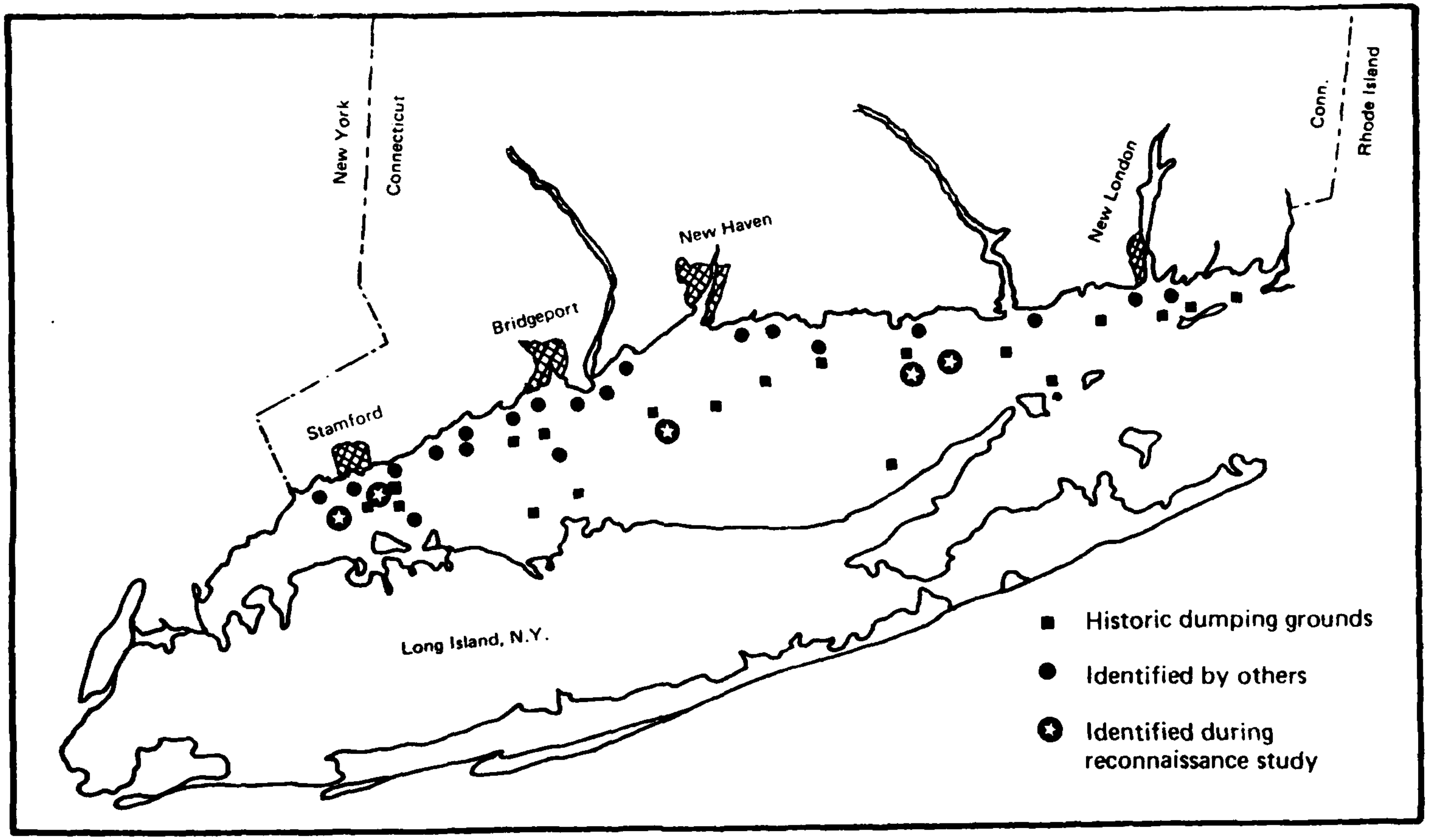


Figure 4–4. Potential nearshore/offshore containment facility locations.

5. Clinton
   - area 6 miles offshore, 2 miles beyond Six Mile Reef
   - roughly 8 square mile area between Six Mile Reef and the Cornfield Shoals dumping ground.

If a large-volume, long-term dredged material containment facility is ever to be constructed in LIS, it will probably have to be sited in an offshore deep water location. The level of detail necessary to pinpoint potential locations could not be developed in this study, but except for the Cable and Anchor Reef site suggested by McAleer, the general locations listed above are considered worthy of further study. During the informal review meeting held with State and Federal representatives, it was pointed out that the 30- to 60-foot isobath in the Sound can be considered to encompass relatively shallow, productive bottomlands. The information available in this study appeared to indicate that at least some areas within the 60-foot isobath are of lower ecological significance and could conceivably be feasible as disposal locations.

The most feasible locations for building large containment facilities may turn out to be those areas previously altered through open water disposal activities. The deep water areas in the vicinity of dumping grounds that are still active under the revised Interim Plan (i.e., New London, New Haven, and Cornfield Shoals) are particularly interesting since none of these dumping grounds conflicts with centers of commercial fishing or shellfishing activity.[1] The Cornfield Shoals area, however, is one of high wave and current energy, which would surely increase foundation

engineering and construction costs relative to other, less dynamic locations. Detailed evaluation of the effects of wave and current energy regimes on containment facility design will be an important part of Stage 2.

SECTION FIVE: FINDINGS OF RECONNAISSANCE EFFORT AND OVERVIEW OF STAGE 2

An assumption implicit in this study is that the containment method of disposal would be used for all dredged materials regardless of whether the land eventually created would be useable. In effect, this study has considered the worst case for containment and has concluded that large-volume containment will be a costly disposal solution with limited opportunity for ultimate land use. There should be no doubt that large-volume containment proposals will be highly controversial as well.

Still, it is possible that containment may be required in LIS for a significant fraction of the material to be dredged in future years as other disposal options are exhausted or foreclosed. If this occurs, then the high costs of containment facilities could become a secondary consideration. A case in point in this regard is the requirement that all dredged material disposal in the Great Lakes region be in containment facilities designed for 10-year capacity. Although disposal costs in the Great Lakes region have increased by as much as an order of magnitude in some instances, containment is required under Federal law (Rivers and Harbors Act of 1970, PL 91-611) and is paid for under a 75 percent Federal/25 percent local cost-sharing formula.

Several concepts for dredged material containment were not examined in this reconnaissance effort and a great deal

of further, more tightly defined study will be conducted during Stage 2 to determine if containment can be part of the solution to the disposal dilemma in LIS. Specifically, opportunities for small-volume, localized containment alternatives for waterfront land creation, marsh creation, dredged material rehandling, and other uses will be assessed. Potential containment projects will be clearly defined in terms of amount and type of material, dredging/disposal schedule, options for ultimate site use, etc. Only then can the many environmental, economic, legal, and institutional factors affecting project feasibility be identified and dealt with progressively. Underscoring all of the above is the necessity to evaluate the role of containment within a multi-purpose, long-range dredged material management plan for LIS.

Findings of Reconnaissance Effort

This study has been concerned with the large-volume containment alternative for long-term dredged material disposal in LIS. In the immediate future, the Corps of Engineers and both Connecticut and New York will attempt to formulate a dredged material management plan for LIS that will effectively balance the competing economic, social, and environmental forces. The selected plan will most likely incorporate several disposal alternatives, and will not depend exclusively on either contained or open water disposal. The continued investigation of the proper role for containment alternatives can benefit from the findings listed below:

1. The sediments and soils in Connecticut's ports and waterways are predominantly fine-grained sands and organic silts. To create useable shoreline land extensions or artificial islands in LIS through containment of this material, it will be necessary to dewater and consolidate the material within the containment facility. State of the art dredged material dewatering/densification techniques[23] (such as progressive trenching, underdrainage, thin lift placement, interior dike construction, sub-areas in parallel and series, etc.) are applicable in the case of shoreline land extensions, but not in the case of large-volume artificial islands located offshore. Hence, the creation of useable artificial islands in LIS through dredged material containment will be virtually impossible, while the creation of useable shoreline land extensions will be feasible, but will require long-term planning and continuous containment area operation and management to facilitate dewatering.

2. In order to convert dredged material islands to some use requiring even low soil bearing capacity, innovative and costly foundation engineering will be needed. Artificial islands can, however, provide a new siting opportunity for water-dependent industrial facilities that have difficulty obtaining sites as developable coastal land inventories decrease. For high revenue-producing land uses, the added construction costs for islands may be less of a development disincentive than would appear to be the case.

3. The possibility of small-volume useable land/island creation projects cannot be evaluated without detailed knowledge of the physical and chemical properties of the sediments and soils in the harbors and potential disposal locations. This is true regardless of the ultimate use intended.

4. The fine-grained sediments characteristic of most Connecticut harbors may be suitable for eventual inland disposal as fill material or sanitary landfill cover. A containment facility designed as a material rehandling facility, with a full-scale operating program to assist dewatering and consolidation, is conceivable. This containment option is attractive where disposal siting is severely constrained since a single, reuseable facility results. The chemical nature of the dewatered sediments, in terms of the leaching potential of salts and other constituents, is unknown at this time.

5. Two containment facility designs appear to be most appropriate for LIS: a simple rock dike and a sheet pile circular cell dike. On a per linea. foot of wall basis, the first cost difference between the two is substantial in shallow water design locations, but is less significant in deeper water, where the sheet pile dike is estimated to be 20 percent more expensive. The rock dike has an indefinite design life and provides rough habitat for marine life. The sheet pile structure must be replaced in 25 to 30 years, but

provides a vertical wall face that allows ship access if desired.

6. A single rock dike containment facility, located in water averaging 36 feet deep at mlw and with capacity to receive all 59 MCY of dredged material projected for Connecticut from 1985 to 2035, would cost in excess of $150,000,000 to design and construct. With interest at 6-7/8 percent, it would be 10 to 15 percent less expensive, on a present worth basis, to build 30 MCY of capacity to start and then add another 30 MCY of capacity in 25 years.

7. For large-volume containment facilities, the potential for siting in shoreline and nearshore locations is very low. Deeper water (say from 30 to 70 feet mlw), offshore locations may be feasible for large sites, particularly locations in the vicinity of historical and still active open water dumping grounds.

8. In the offshore siting location, the largest facility examined in this study would remove about 680 acres of LIS bottomland from the ecosystem. At present, the three active open water dumping grounds (New London, New Haven, and Cornfield Shoals) in LIS encompass over 2,500 acres of bottomland. The largest rock dike designed in this study would add about 40 acres of rough, rocky habitat to the marine ecosystem.

9. Decision-making for facility siting should not be made solely on the basis of ecological value. Many technical, environmental, economic, and social tradeoffs will have to be made if alternatives to open water disposal in LIS are to be found.

10. A truly meaningful analysis of potential containment facility locations cannot be conducted outside the perspective of a comprehensive dredged material management plan for LIS. Basic design parameters (especially material volume, physical/chemical quality, and dredging logistics) must be specified and detailed site-specific data on potential locations must be compiled. A rigorous selection methodology is needed and participation from all government levels is essential. Detailed site selection procedures should be established and carried out during Stage 2 planning.

11. The development of a comprehensive dredged material management plan for LIS has progressed to the point where the joint New York/Connecticut Interim Plan of early 1977 has been slightly revised in recent meetings by an interagency coordinating committee. The revised Interim Plan is now being drafted by the New England River Basins Commission and is expected to become part of its Comprehensive Coordinated Joint Plan for New England during 1979.

12. At the present time, no waste disposal activities other than for dredged material are permitted in LIS. Substantial quantities of various solid waste materials are generated annually in Connecticut, including 73,000 tons per year (TPY) miscellaneous chemicals; 10,600 TPY solid plastics and resins; 13,600 TPY municipal/industrial sludges; construction and demolition debris; and municipal solid wastes. The desirability and economic feasibilty of depositing these waste materials in a dredged material containment facility are unknown, but questionable, at this time.

Overview of Stage 2

In order to proceed toward a definitive Stage 3 evaluation of dredged material containment in Long Island Sound, the Stage 2 planning effort will identify and evaluate a broad range of possible containment concepts. The emphasis during Stage 2 will be on plan formulation and evaluation. At the end of Stage 2, a set of realistic, well-defined containment alternatives will be designated for further consideration in Stage 3.

During the final stage of planning, the designated alternatives will be developed into specific dredged material management programs with complete technical designs, institutional arrangements, and operational plans. Furthermore, the socioeconomic, environmental, land use and other

impacts of the alternatives will be assessed in detail through the EIS process. At the end of Stage 3, the basis for selecting a Long Island Sound containment plan will be complete and a decision will then be made by the Division Engineer.

Public participation and coordination with review, regulatory and planning agencies will be extensive during both Stages 2 and 3. An early and active program of public involvement and interagency coordination is recognized as essential to the success of the entire planning effort and, ultimately, to plan implementation. Public and agency perceptions will be fully reflected in the formulation and evaluation of alternative containment plans. In fact, plan formulation at the start of Stage 2 will be based, in part, on potential containment opportunities identified through local workshops.

Plan Formulation Approach

The Stage 2 effort will begin with the basic process of establishing a clear set of planning objectives. This will be accomplished through the performance of two highly interdependent tasks: (1) problem (and opportunities) identification; and (2) formulation of alternative dredged material containment plans.

Initially, the task of problem identification will be approached at management levels of cognizant local, State, and Federal agencies. Preliminary work plans for the

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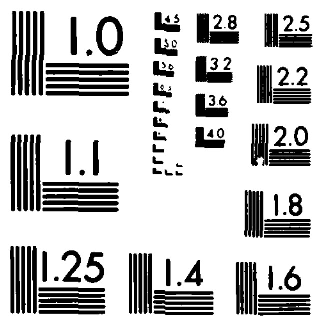
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Stage 2 effort will be offered for comment and participants will have an opportunity to provide input at the start of the planning process. An important objective of Stage 2 is to define the role of containment within the overall, comprehensive dredged material management plan for LIS now evolving. Early Stage 2 involvement by the agencies developing the overall plan is necessary to achieve that objective.

Subsequently, and more importantly, problem identification will be a critical aspect of the difficult task of formulating alternative plans for dredged material containment in LIS. Containment alternatives can be proposed for a number of purposes, including the following:

1. Containment for the sole purpose of isolating contaminated sediments from the ecosystem, with no plans for eventual facility or material use.

2. Containment for useable waterfront land creation.

3. Containment for useable island creation, perhaps as part of an island habitat development project.

4. Containment for the purpose of storing material for eventual use in construction, agriculture, land reclamation, or sanitary landfills.

5. Containment in conjunction with projects to develop marsh or terrestrial habitat.

Considerable emphasis will be placed on specifically defining the purposes of various containment schemes. With

containment objectives clearly known, the alternatives can be outlined and refined for problem identification, impact assessment, and evaluation. The evaluation of containment options will not be possible unless specific containment plans are proposed. This means that basic design features--such as required containment volume, active disposal life, and material source(s) and quality--as well as plans for facility operation, maintenance, and eventual use must be established.

It should be noted that, during Stage 2, detailed engineering designs of alternatives will not be prepared. However, all engineering, environmental, institutional, and other factors associated with each alternative will be developed to a comparable level of detail sufficient for the public and official authorities to review and understand the rationale used in formulating and screening the alternatives.

The alternative containment plans to be evaluated during Stage 2 will encompass small-volume, localized opportunities as well as large-volume options of regional character. The process of formulating alternatives will include a series of local-level workshops to solicit local official and citizen input into the containment facility planning and siting process. These local workshops will serve the purpose of ensuring that alternative containment plans reflect a broad spectrum of public and agency concerns.

Plan Evaluation Framework

The local workshops and other public and agency involvement activities will be an important part of problem (and

opportunity) identification throughout Stage 2. Containment facility planning for LIS and the densely developed Connecticut coast, particularly for multiobjective disposal-productive use facilities, will be a complex undertaking. It will be important, during early planning activities, to identify both the issues likely to be the basis for opposition to a plan and the agencies or groups likely to raise the issues. Then, impact assessment and evaluation tasks can be structured to deal with critical issues before plans are well-advanced.

Since the Stage 2 effort will focus on containment for land/island creation, the planning and evaluation process will jointly consider containment facility planning with productive use (e.g., industrial, recreational) planning whenever possible. The feasibility and operational viability of a productive site use concept can be greatly affected by the design features of the containment facility. For example, the physical planning characteristics of a project (i.e., foundation conditions, configuration, shipping and rail access, utility availability) can be used to enhance eventual site productive development potential. It is also important that proposals for ultimate productive development of waterfront lands or islands created with dredged material reflect good land use planning practice. Productive use plans should, at a minimum, be compatible with adjacent land and water uses; consistent with local master plans and zoning regulations; and contribute to established community land use needs.

The outcome of the Stage 2 effort will be affected by many factors, both substantive and procedural, associated

with each alternative containment plan. The set of overall implementation factors listed in Table 5-1 will provide a framework for ensuring that the full range of substantive and procedural considerations affecting the feasibility of alternative plans is addressed during Stage 2.

A number of specific Stage 2 study areas were identified during this reconnaissance effort and are described briefly below.

Site Selection Methodology

A comprehensive methodology for identifying and evaluating potential containment facility locations needs to be developed and applied during Stage 2. The preliminary siting analysis described previously in Section Four provides a base from which more detailed siting work can proceed. Specific siting opportunities for shoreline containment options, and perhaps for nearshore island creation, will be identified primarily through public workshops and interagency meetings held at the local level. Finding and evaluating deeper water, offshore siting locations will require another approach.

The concept of mapping the physical and biological characteristics of the sediments in the Sound to identify and quantify various habitat types was suggested in discussions with State and Federal officials during the Stage 1 effort. With detailed bottom habitat data, decisions based on preserving relatively scarce or fragile habitats could conceivably be made. Of course, such data would be

TABLE 5-1

FACTORS AFFECTING CONTAINMENT PLAN FEASIBILITY AND IMPLEMENTATION

ENVIRONMENTAL

1. Ecological characteristics of proposed containment facility location
2. Environmental impacts of dredging and land/island creation
3. Dredged material pollution properties

TECHNICAL

1. Dredged material structural properties
2. Containment area sub-surface conditions
3. Containment facility design and operating characteristics
4. Site size and configuration (as related to productive use)
5. Technical coordination of disposal plan with productive use plan

ECONOMIC/FINANCIAL

1. Economic or social benefits (costs) of the plan
2. Engineering and construction costs
3. Dredged material transport costs
4. Fees or taxes on dredged material
5. Project sponsor or site owner capability to assume financial responsibilities

LEGAL

1. Conformance with regulatory requirements
2. Adequacy of environmental impact statement
3. Disposal rights to the site
4. Site ownership authorities (as related to productive use)
5. Land use restrictions

TABLE 5-1 (CONT.)

INSTITUTIONAL

1. Public participation in plan formulation and evaluation
2. Coordination with local project sponsor
3. Coordination with review/regulatory agencies
4. Coordination with planning agencies
5. Procedures for identifying and resolving objections to the plan
6. Corps and other participant attitudes
7. Political, business, and public support

PLANNING/IMPLEMENTATION

1. Relationship to comprehensive LIS dredged material management plan
2. Relationship to long-range environmental plan for LIS
3. Dredging project specification
4. Temporal coordination of disposal plan with productive use plan
5. Availability of environmental data
6. Impacts of land/island creation project on existing water uses
7. Proposed use compatibility with adjacent land uses and local master plans
8. Proposed use compatibility with available transportation systems and infrastructure (if appropriate)
9. Proposed site plan compatibility with site physical features and user requirements (if appropriate)
10. Commitment to proposed land use plan

costly to acquire and would be only one of many types of information used during site review and selection. The importance of rigorous site selection procedures during Stage 2 and 3 planning is obvious and establishment of an acceptable methodology will be a priority Stage 2 study area.

Sediment Analysis

During the formulation and evaluation of alternative containment plans, it will be necessary to have a full understanding of the chemical and physical properties of the material to be dredged. Differences in sediment properties from one area to another may be an important determinant of alternatives to be pursued. Furthermore, for waterfront land creation options, sediment characteristics will dictate the extent of the dewatering/densification or other operations necessary to create useable land.

Financial Responsibility

The issue of financial responsibility for containment facilities will be very important to resolve early in the planning process. The current national policy requires local (dredging) project sponsors to select, finance, and construct dredged material containment areas. On a navigation project-by-project basis, the policy is applicable. However, in the case of a containment facility planned to receive material dredged from several harbors, financial responsibility will have to be established.

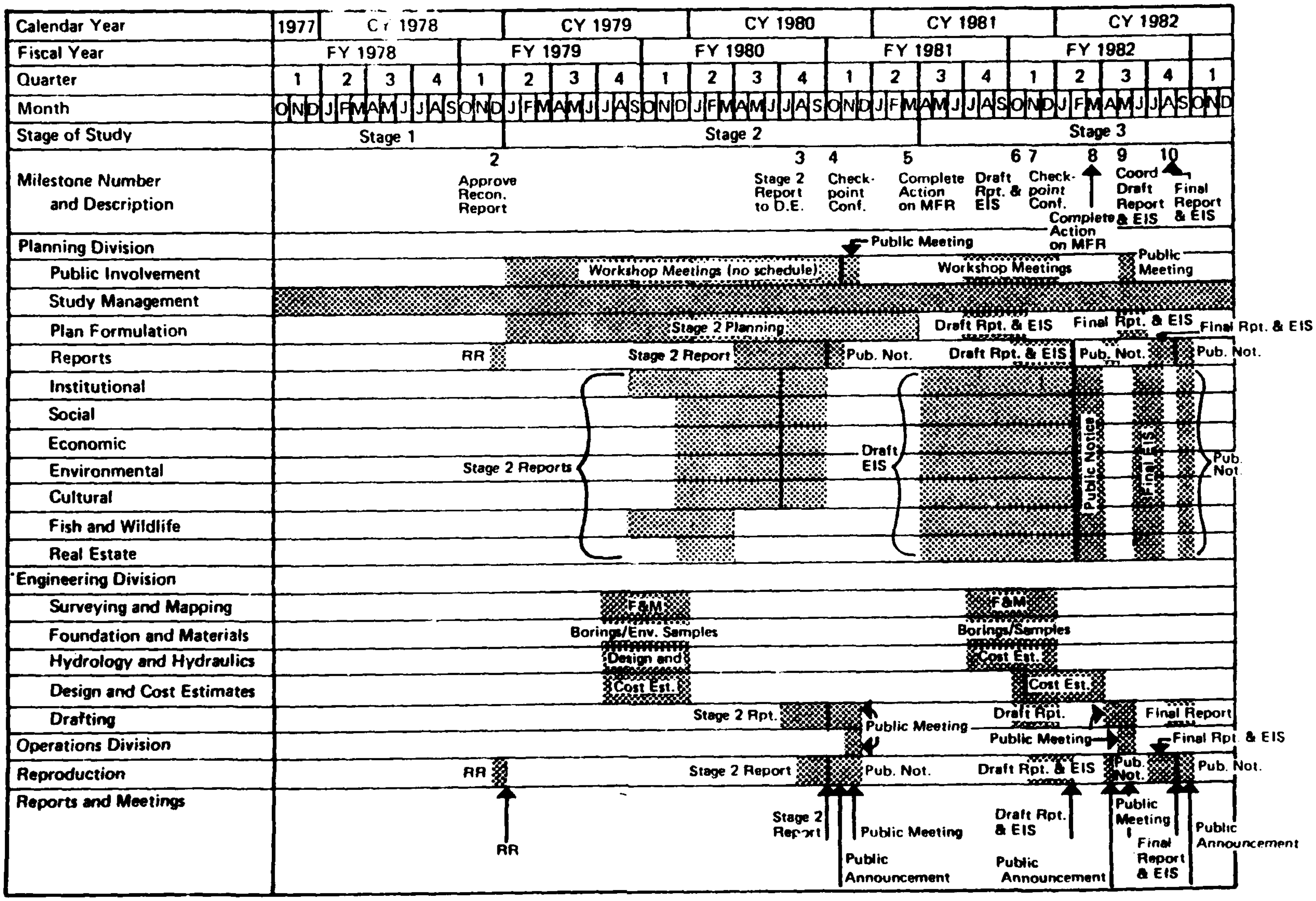
Ownership

If useable land is created through dredged material disposal, the ownership of that land will be at issue. This is an important consideration when attempting to combine a disposal project with an eventual industrial or commercial land use. In some States, land created with State-owned bottomlands must be developed for public use by law. The extent to which this could be a problem in Connecticut is not known at this time, but will be determined during Stage 2.

Preliminary Schedule

A preliminary schedule for conducting Stage 2 and Stage 3 planning for dredged material containment in LIS is given in Figure 5-1. A management strategy for sub-dividing the Stage 2 effort into specific work plans and for coordinating the performance of all work is being developed at this time (January 1979). The management strategy will include a more detailed schedule for Stages 2 and 3.

Figure 5—1. Plan of study on dredged material containment in Long Island Sound.



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APPENDIX A

FEDERAL DREDGING PROJECTS - 1947 TO 1977

Table A-1 is an inventory of NED improvement and maintenance dredging in Connecticut since 1947. To obtain data on existing Federal navigation projects, four sources were consulted:

1. New England Division, Corps of Engineers, contract activity summaries for Rivers and Harbors Branch, 1958 to 1970 and 1971 to 1977.

2. Plans and specifications for each project as contracted out from 1958 to 1977.

3. U.S. Army Corps of Engineers annual reports on civil work activities, 1951 to 1977.

4. NED, Rivers and Harbors Branch personnel.

The contract activity summaries contained the project name, contract number and date, the contractor who performed the dredging, the contract value and yardage to be removed, and the actual payment and pay yardage removed. These records covered all NED projects since 1958.

The plans and specifications were used mainly to ascertain the disposal sites for the dredged material. According to the contractor's equipment, and according to

any special provisions for disposal contained in the plans and specs, the disposal method (either land or sea) and the disposal location were determined. When the disposal method was at sea, the particular dumping site was specified. When disposal was on land, the plans and specs in many cases cited two or even three disposal sites clustered around the dredging site. The extent to which these sites were utilized could not be determined from the plans and specs because the disposal method was left to the discretion of the contractor. In the case where only one land disposal site was specified, it was assumed that disposal occurred on that location.

The annual reports provided backup to the cost and volume figures from the contract activity summaries, as well as cost and volume figures for 1951 to 1957. The annual reports do not generally include data for the disposal method, contractor or contract number,and so for the period of 1951 to 1957, these data are not given. Personnel in the Rivers and Harbors Branch were able to pinpoint disposal sites and methods of disposal for recent projects due to their close association with the conduct of the Federal dredging contracts.

Except where indicated, only those costs associated with the actual contract are included in the data. In-house Corps supervision and administration costs are not included. The yardages specified are pay yardages and any non-allowable overdepth that may have been dredged by the contractor is not included. Thus, the yardage figures underestimate the total amount actually dredged. In some cases, the overdepth is small, but in others, it may be quite large. One contract involved over 500,000 CY pay yardage, but the contractor

dredged an additional 500,000 CY non-pay yardage. Since there is no reliable method of estimating non-pay yardages for all projects, no such estimates are included herein.

TABLE A-1

INVENTORY OF CORPS OF ENGINEER IMPROVEMENT AND MAINTENANCE DREDGING IN CONNECTICUT (1947-1977)

CONNECTICUT COASTAL AREA	PROJECT NAME (AND MAP NUMBER)	IMPROVEMENT OR MAINTENANCE	YEAR	VOLUME (CY)	COST ($)	$/CY	METHOD OF DISPOSAL	DISPOSAL TRANSPORT DISTANCE	TYPE OF MATERIAL	DREDGE PLANT
Western Coastal Area (including Housatonic River)	Greenwich Harbor (158)	I	1949[a]	302,700	176,644	0.58	-	-	Mud	-
			1950[a]	105,300	65,200	0.62	-	-	Mud	-
		M	1968	39,800	58,860	1.48	Open water	5 miles	Ordinary	Clamshell
	Mianus River (157)	I	1951	211,140	111,020	0.53	-	-	Mud	-
		M	1964	19,730	44,960	2.28	Open water	6 miles	Ordinary	Clamshell
	Stamford Harbor (156)	M	1963	121,250	161,490	1.33	Open water	9 miles	Ordinary	Dipper
	Westcott Cove (155)	M	1963	8,500	19,890	2.34	Open water	9 miles	Ordinary	Clamshell
	Fivemile River Harbor (154)	M	1968	47,700	70,560	1.48	Open water	3 miles	Ordinary	Clamshell
	Norwalk Harbor (152/1)	I	1949[a]	102,190	113,344	1.11	-	-	Mud	-
			1950[a]	75,280	32,330	0.43	-	-	Ordinary	-
		M	1954	214,500	149,890	0.70	-	-	Ordinary	-
			1956	73,730	84,788	1.15	-	-	Ordinary	-
			1960	86,000	110,080	1.28	Open water	5 miles	Ordinary	Clamshell
			1964	184,720	200,650	1.09	Open water	5 miles	Ordinary	Clamshell
			1969	63,220	107,480	1.70	Open water	5 miles	Ordinary	Clamshell

[a] Same project performed over more than one year.

TABLE A-1 (CONT.)

CONNECTICUT COASTAL AREA	PROJECT NAME (AND MAP NUMBER)	IMPROVEMENT OR MAINTENANCE	YEAR	VOLUME (CY)	COST ($)	$/CY	METHOD OF DISPOSAL	DISPOSAL TRANSPORT DISTANCE	TYPE OF MATERIAL	DREDGE PLANT
Western	Westport Harbor & Saugatuck River (151)	M	1970	25,870	96,770	3.74	Open water	5 miles	Ordinary	Dipper
	Southport Harbor (146)	M	1948	25,300	29,700	1.17	-	-	Ordinary	-
			1962	48,070	66,750	1.39	Open water	5 miles	Ordinary	Clamshell
	Bridgeport Harbor (143/1)	I	1962	675,150	643,800	0.95	Land	<1 mile	Ordinary	Hydraulic
			1962	1,388,730	930,450	0.67	Open water	5 miles	Ordinary	Hopper
			1963	25,870	54,300	2.10	Open water	5 miles	Ordinary	Clamshell
		M	1953	31,420	29,680	0.94	-	-	Mud, silt	-
			1955	263,610	-	-	-	-	Ordinary	-
			1956	131,450	-	-	-	-	Ordinary	-
			1956	500,670	-	-	Open water	5 miles	Ordinary	Hopper
			1960	347,000	125,838	0.36	Open water	5 miles	Ordinary	Hopper
			1960	87,770	-	-	Open water	5 miles	Ordinary	Hopper
	Housatonic River (142)	I	1956[a]	1,306,050	568,227	0.44	-	-	-	-
			1956[a]	669,460	262,430	0.39	-	-	-	-
		M	1953	24,270	36,310	1.50	-	-	-	-
			1960	132,310	113,071	0.85	Open water	8 miles	Ordinary	Clamshell
			1976	215,000	1,191,100	5.54	Land	<1 mile	Org. silt	Hydraulic
Central Coastal Area (including Connecticut River)	Milford Harbor (141)	M	1948	38,680	42,686	1.11	-	-	Ordinary	-
			1956	52,850	63,660	1.20	-	-	Ordinary	-
			1967	37,050	56,280	1.52	Open water	6 miles	Ordinary	Clamshell

TABLE A-1 (CONT.)

CONNECTICUT COASTAL AREA	PROJECT NAME (AND MAP NUMBER)	IMPROVE-MENT OR MAINTE-NANCE	YEAR	VOLUME (CY)	COST ($)	$/CY	METHOD OF DISPOSAL	DISPOSAL TRANSPORT DISTANCE	TYPE OF MATERIAL	DREDGE PLANT
Central	New Haven Harbor (139)	I	1948	2,326,720	510,680	0.22	-	-	Sand, gravel	-
			1949	701,350	163,980	0.23	-	-	Sand, gravel	-
			1949	218,090	101,090	0.46	-	-	Sand, gravel	-
			1949	4,616,570	1,674,320	0.36	-	-	Sand, gravel	-
		M	1950	180,850	150,860	0.83	-	-	Clay, sand	-
			1955	153,580	81,800	0.53	Open water	-	Ordinary	-
			1957	141,950	-	-	Open water	-	Ordinary	Hopper
			1957	66,100	-	-	Open water	-	Ordinary	-
			1957	201,900	-	-	Open water	-	Ordinary	-
			1957	690,000	669,020	0.97	Open water	-	Ordinary	Hopper
			1960	37,000	32,110	0.87	Open water	-	Ordinary	Hopper
			1961	97,680	60,350	0.62	Open water	-	Ordinary	Hopper
			1963	83,340	142,300	1.71	Open water	7 miles	Ordinary	Clamshell
			1964	250,540	354,720	1.42	Open water	7 miles	-	Clamshell
			1965	77,000	85,800	1.11	Open water	7 miles	-	Clamshell
			1967	147,860	193,810	1.31	Open water	7 miles	Ordinary	Clamshell
			1968	2,150	105,260	-	Open water	7 miles	Boulders	Clamshell
			1974	200	74,300	-	Open water	<1 mile	Rock	-
			1974	945,000	1,653,750	1.75	Open water	7 miles	Org. silt	Clamshell
			1977	88,200	375,450	4.26	Land	<1 mile	Org. silt	Hydraulic
	Branford Harbor (137)	M	1956	19,000	132,180		Open water	8 miles	Ordinary	Clamshell
			1956	83,220		1.29	Land	<1 mile	Ordinary	Hydraulic
			1965	93,240	176,890	1.90	Open water	8 miles	-	Clamshell
			1976	62,140	172,000	2.77	Land	<1 mile	Org. silt	Hydraulic
	Stony Creek (136.57)	I	1969	76,000	117,040	1.54	Open water	8 miles	Ordinary	Clamshell
		M	1977	32,730	179,190	5.47	Open water	10 miles	Org. silt	Clamshell
	Guilford Harbor (136.3)	M	1964	86,150	110,460	1.28	Land	<1 mile	-	Hydraulic
			1974	71,800	233,350	3.25	Open water	13 miles	Org. silt	Clamshell

TABLE A-1 (CONT.)

CONNECTICUT COASTAL AREA	PROJECT NAME (AND MAP NUMBER)	IMPROVEMENT OR MAINTENANCE	YEAR	VOLUME (CY)	COST ($)	$/CY	METHOD OF DISPOSAL	DISPOSAL TRANSPORT DISTANCE	TYPE OF MATERIAL	DREDGE PLANT
Central	Clinton Harbor (136)	I	1949	48,780	27,125	0.55	-	-	Sand, mud	-
			1950	80,470	39,690	0.49	-	-	Sand, mud	-
		M	1957	50,000	160,950	3.20	-	-	Ordinary	-
			1965	27,600	61,850	2.24	Open water	3 miles	Ordinary	Clamshell
			1972	31,100	71,470	2.30	Land	<1 mile	Org. silt	Hydraulic
			1976	8,250	40,000	4.85	-	-	Sand	Sidecast
	Duck Island Harbor	M	1949	132,540	31,630	0.24	-	-	-	Hopper
	Patchogue River	I	1956	193,730	203,640	1.05	-	-	-	-
		M	1963	42,420	40,150	0.95	Open water	4 miles	Ordinary	Clamshell
			1972	42,590	58,350	1.37	Land	<1 mile	Org. silt	Hydraulic
			1976	10,870	32,760	3.01	-	-	Sand	Sidecast
			1977	36,500	157,750	4.32	Land	-	Org. silt	Hydraulic
	Connecticut River below Hartford (133/1-133/7)	I	1963	139,340	128,820	0.92	Land	<1 mile	-	Hydraulic
			1965	536,340	336,970	0.63	Open water	5 miles	-	Clamshell
		M	1949	381,550	250,692	0.66	-	-	Sand, clay	-
			1952	155,680	125,150	0.80	-	-	Sand, gravel	-
			1953	356,500	206,080	0.58	-	-	-	-
			1956	301,290	276,030	0.92	-	-	-	-
			1958	144,690	184,107	1.27	-	-	-	-
			1959	140,380	121,710	0.87	Land	<1 mile	-	Hydraulic
			1961	204,340	187,470	0.92	Land	<1 mile	Ordinary	Hydraulic
			1964	70,900	69,030	0.97	Open water	5 miles	Ordinary	Hopper
			1964	164,270	203,560	1.24	Land	<1 mile	-	Hydraulic
			1968	147,150	208,320	1.42	Land	<1 mile	Ordinary	Hydraulic
			1970[a]	112,180	364,590	3.25	Open water	3 miles	Ordinary	Clamshell
			1971[a]	176,030	320,370	1.82	Land	<1 mile	Ordinary	Hydraulic
			1973	140,300	202,930	1.45	Land	<1 mile	-	Hydraulic
			1974	85,850	79,200	0.92	Open water	3-4 miles	-	Hopper
			1976	32,000	109,000	3.41	Nott Island	<1 mile	-	Hydraulic
			1976	200,000	488,990	2.44	Land	<1 mile	-	Hydraulic
			1977	129,000	356,040	2.76	Open water	5 miles	-	Clamshell
			1977	158,200	456,970	2.89	Open water	5 miles	-	Clamshell

TABLE A-1 (CONT.)

CONNECTICUT COASTAL AREA	PROJECT NAME (AND MAP NUMBER)	IMPROVE-MENT OR MAINTE-NANCE	YEAR	VOLUME (CY)	COST ($)	$/CY	METHOD OF DISPOSAL	DISPOSAL TRANSPORT DISTANCE	TYPE OF MATERIAL	DREDGE PLANT
Eastern Coastal Area (including Thames River)	Niantic Bay & Harbor (132.1)	I	1970	31,010	89,310	2.88	Open water	4 miles	-	Clamshell
	Thames River (132)	M	1949	219,630	274,600	1.25	-	-	Mud, sand	-
			1954	154,480	136,260	0.88	-	-	Ordinary	-
			1957	20,030	43,020	2.15	-	-	Ordinary	-
			1966	237,390	223,360	0.94	Open water	9 miles	-	Clamshell
	Mystic River (129)	I	1956	109,620	141,400	1.29	-	-	Ordinary	-
		M	1956	17,200	27,240	1.58	-	-	Ordinary	-
	Stonington Harbor (128)	I	1957	28,370	37,800	1.33	-	-	-	-
	Pawcatuck River (127.1)	I	1949	28,310	28,890	1.02	-	-	Sand, gravel	-
			1949	177,650	79,810	0.45	-	-	Sand, gravel	-
		M	1955	29,720	44,220	1.49	-	-	Ordinary	-
			1961	10,170	31,850	3.13	Open water	3 miles	-	Clamshell
			1977	12,810	90,940	7.09	-	-	Sand	Sidecast

APPENDIX B

FEDERAL PROJECT DISPOSAL LOCATIONS

Figures B-1 through B-10 are Corps project maps on which the locations of historical land disposal sites have been indicated. In some cases, the project plans and specs included more than one disposal location and, since the disposal site ultimately used could not be determined, each of the alternatives has been plotted.

In the western coastal area of Connecticut, only two projects involving land disposal sites were noted during data collection. One was a 1962 improvement job in Bridgeport Harbor for which the disposal location information was not available. The other was a 215,000 CY maintenance job in the Housatonic River for which three land disposal locations were indicated (Figure B-1). All other western area projects involved open water disposal.

In the central coastal area, land disposal sites were noted in conjunction with six projects: 1977 maintenance in New Haven Harbor (Figure B-2); 1956 and 1976 maintenance in Branford Harbor (1976 site, Figure B-3); 1964 maintenance in Guilford Harbor (site location unknown); 1972 maintenance in Clinton Harbor (Figure B-4); 1972 and 1976 maintenance in Patchogue River (1976 site, Figure B-5); and eight maintenance projects in the Connecticut River since 1959 (1964 and 1976 sites, Figures B-6 through B-10). Since 1968, over

60 percent of the dredged material in the central area has been disposed in open water.

No land disposal projects were found in the eastern coastal area, but about 30 percent of the material dredged there since 1968 has been sidecast-dredged for shoreline disposal (beach nourishment).

CORPS OF ENGINEERS

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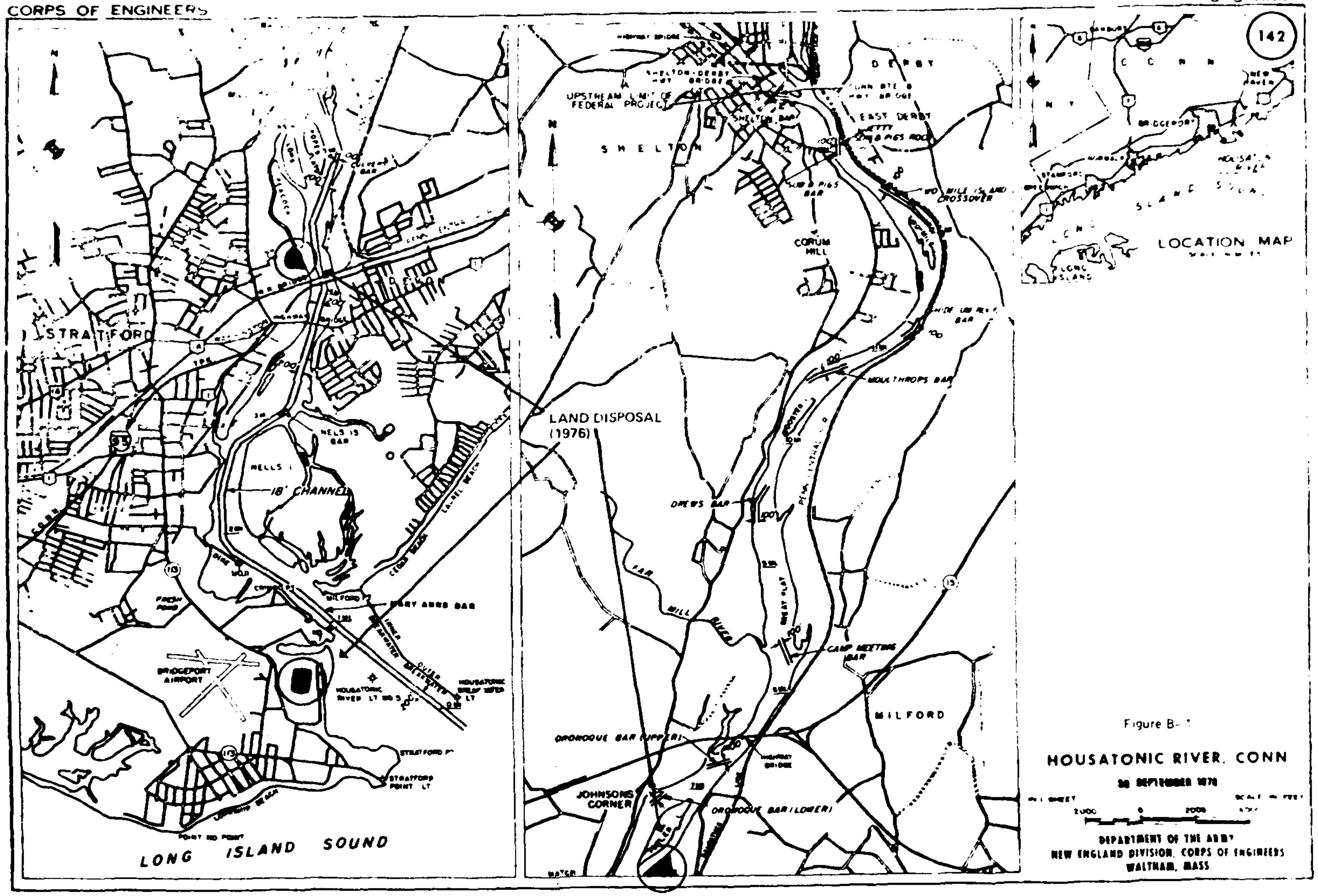


Figure B-1

HOUSATONIC RIVER, CONN

30 SEPTEMBER 1970

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

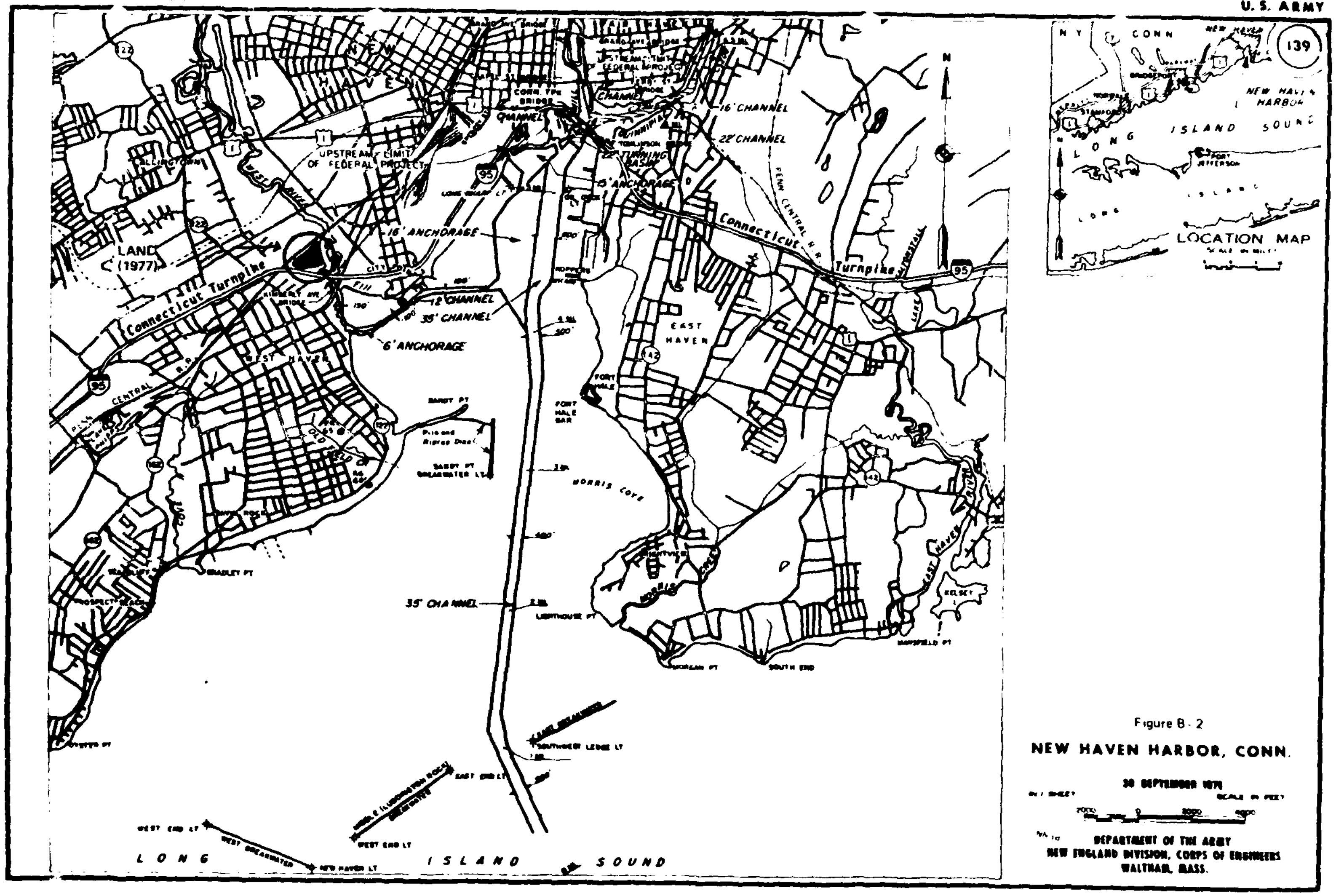
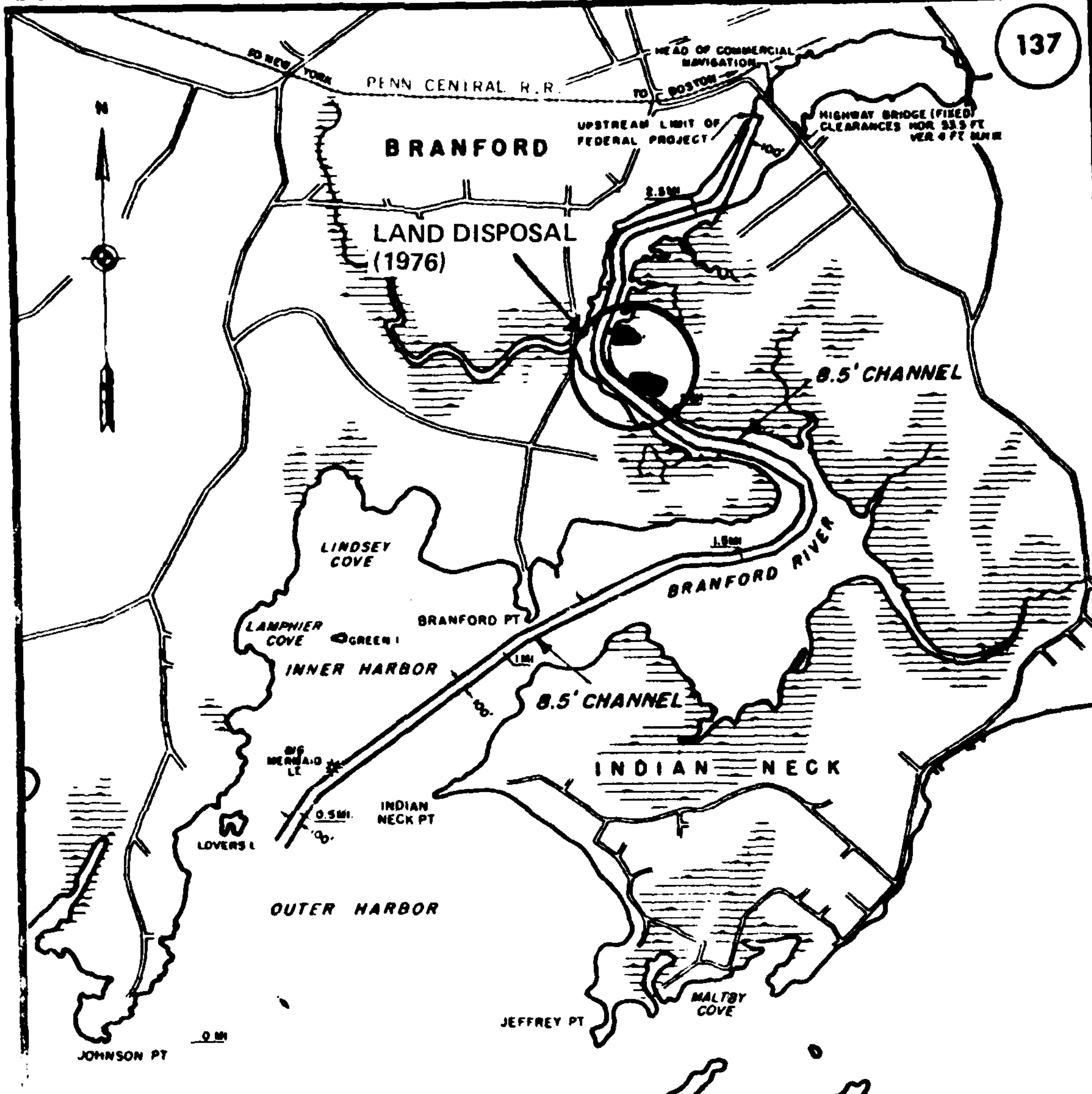


Figure B-2

NEW HAVEN HARBOR, CONN.

30 SEPTEMBER 1979

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.



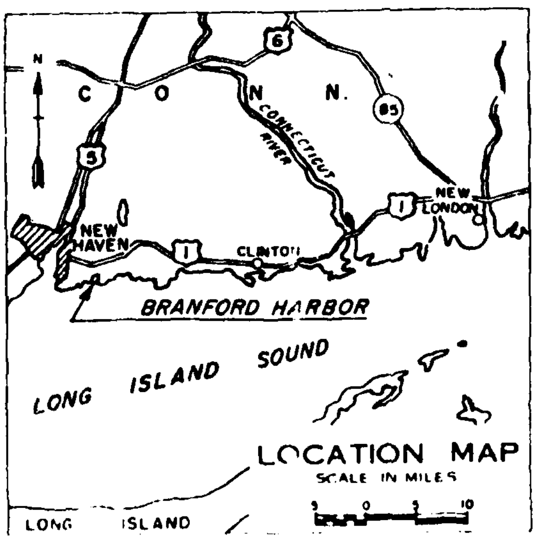


Figure B–3.

BRANFORD HARBOR CONNECTICUT

30 SEPTEMBER 1976

IN 1 SHEET

1000 0 1000 2000 FT

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

CORPS OF ENGINEERS U. S. ARMY

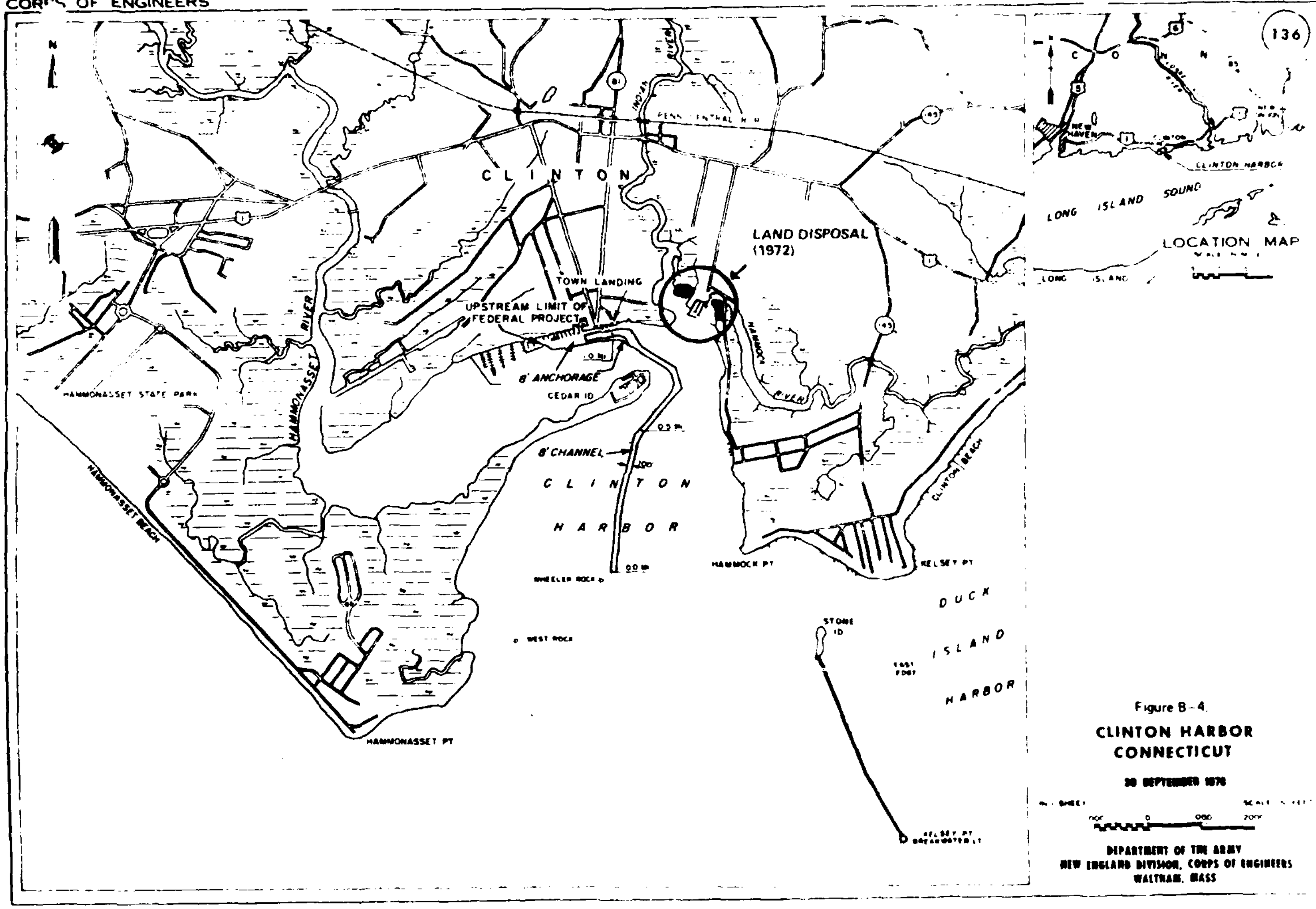


Figure B-4.

CLINTON HARBOR
CONNECTICUT

30 SEPTEMBER 1976

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS

CORPS OF EN NEERS U. S. ARMY

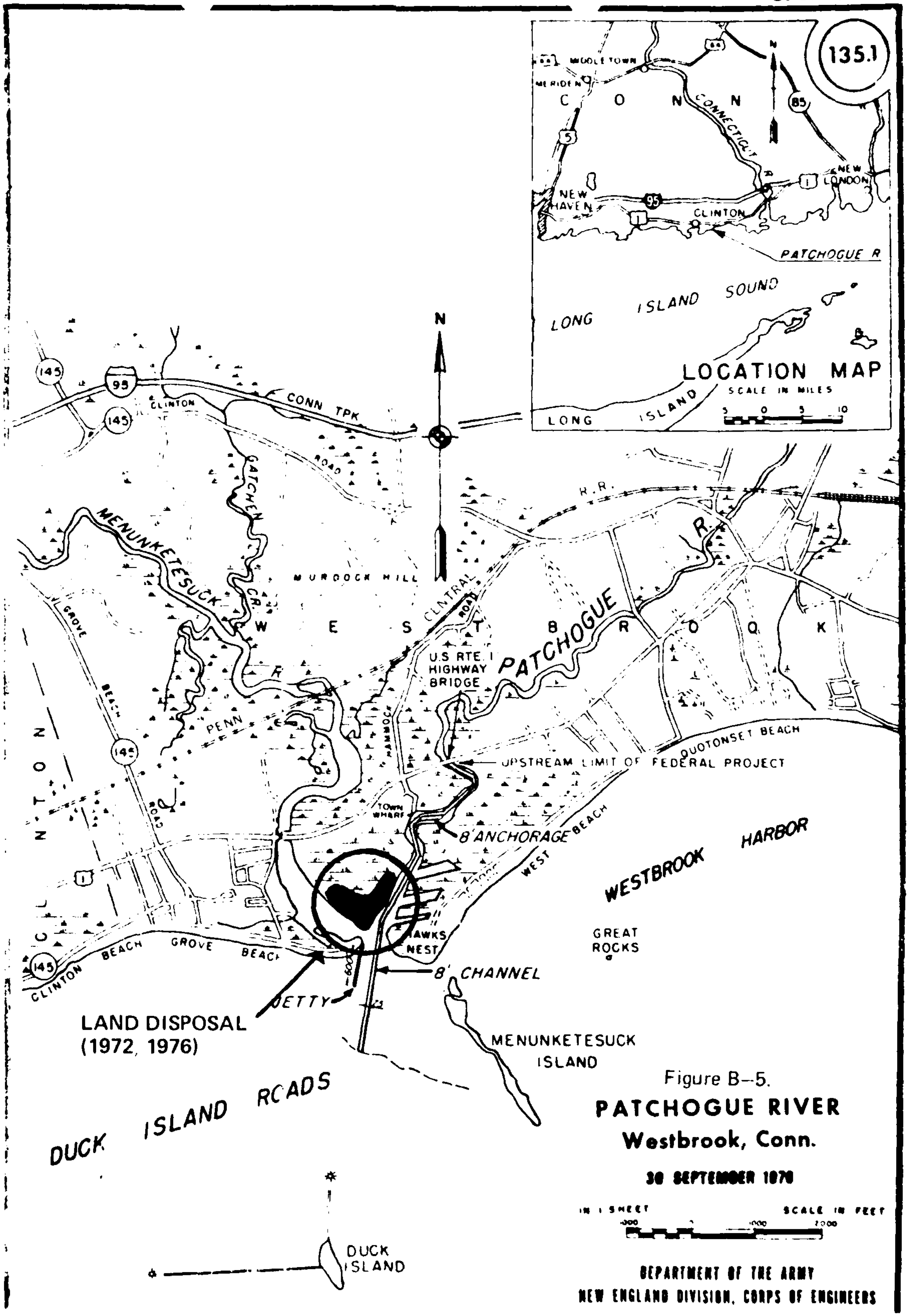
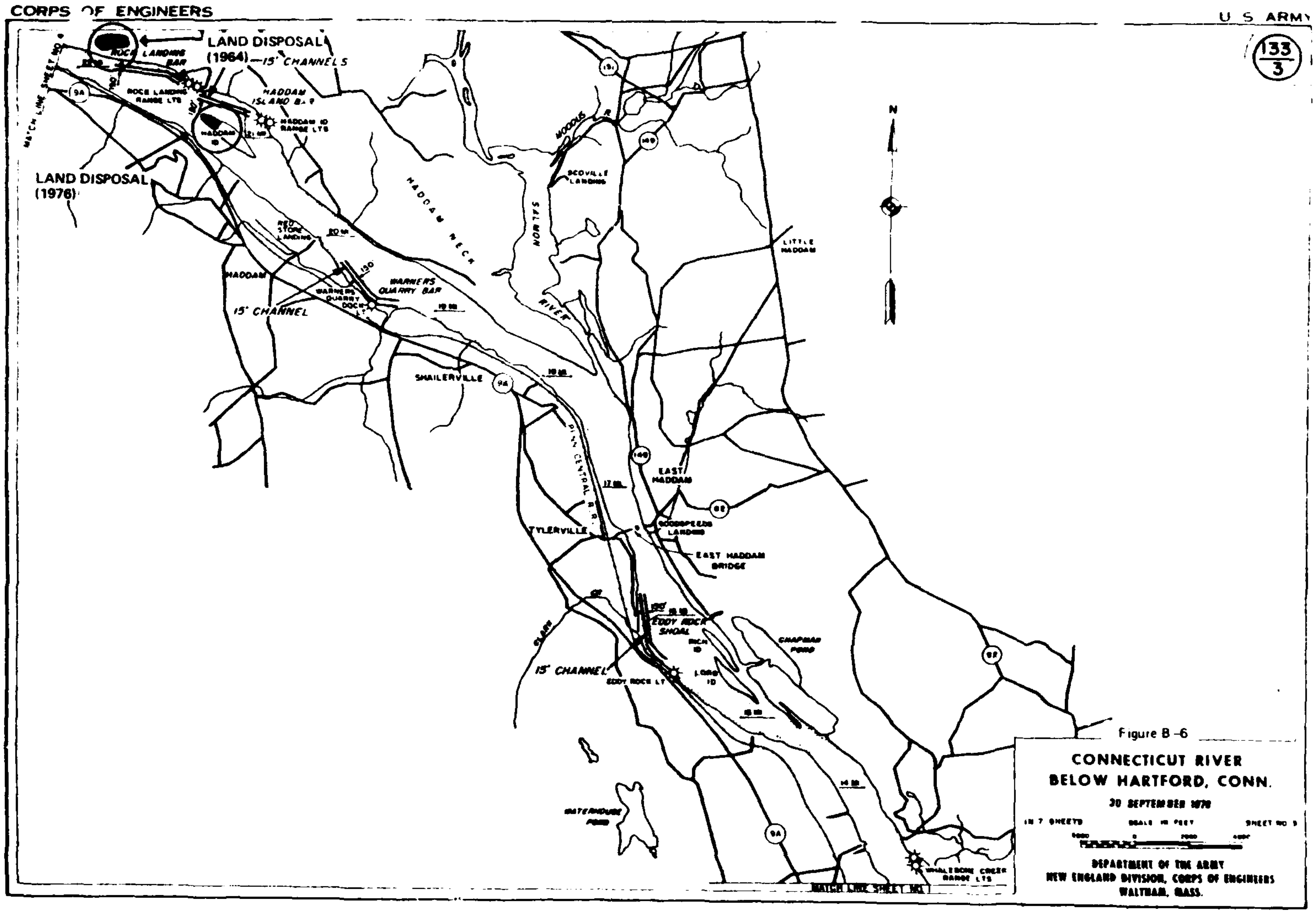


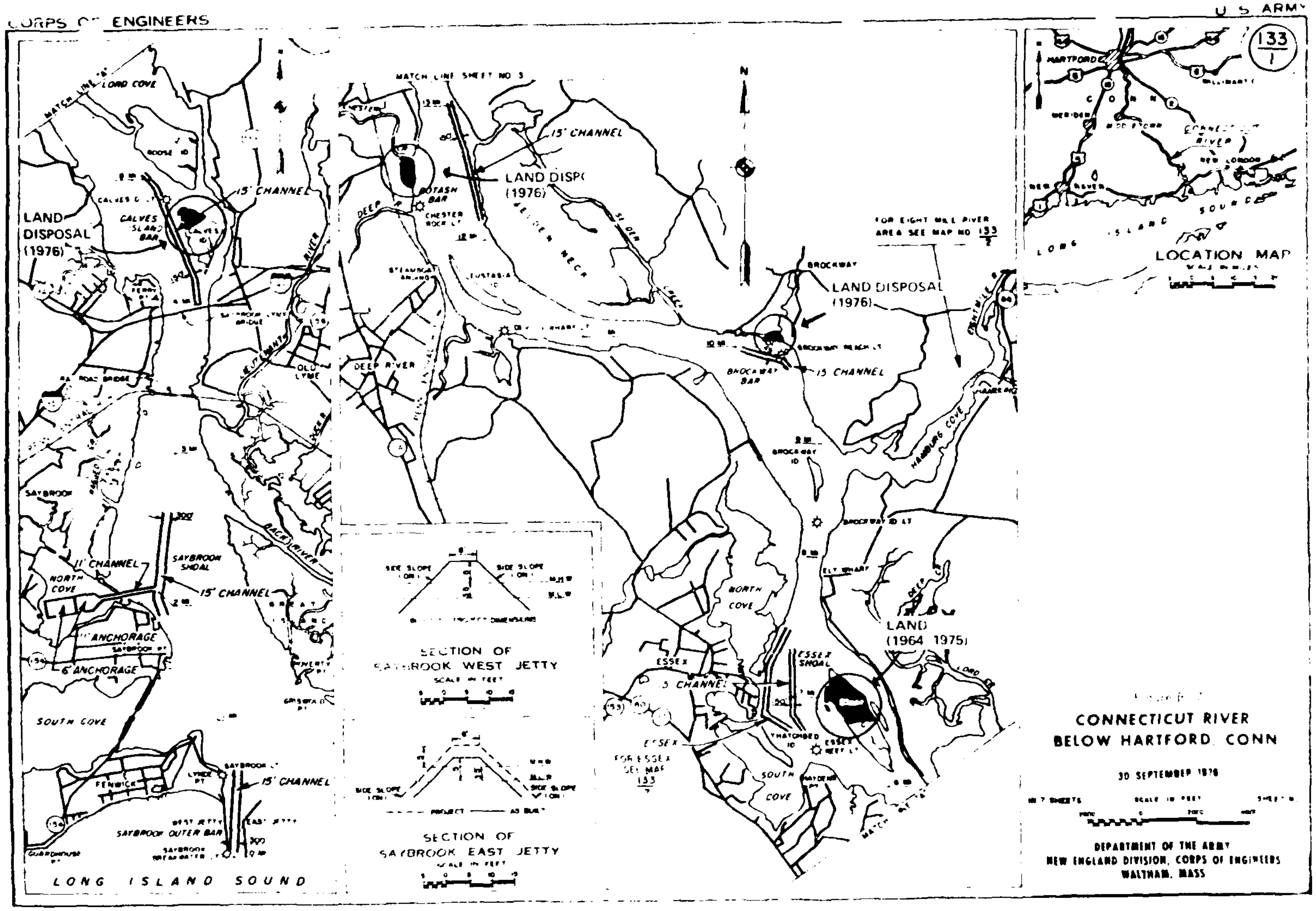
Figure B–5.

PATCHOGUE RIVER
Westbrook, Conn.

30 SEPTEMBER 1970

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS


CORPS OF ENGINEERS
U S ARMY
133
3
LAND DISPOSAL (1964)
15' CHANNELS
ROCK LANDING BAR
ROCK LANDING RANGE LTS
HADDAM ISLAND B. 9
HADDAM ID RANGE LTS
HADDAM ID
LAND DISPOSAL (1976)
RED STONE LANDING
HADDAM
WARNERS QUARRY BAR
WARNERS QUARRY DOCK LT
15' CHANNEL
HADDAM NECK
SALMON RIVER
MOODUS R.
SCOVILLE LANDING
LITTLE HADDAM
SHAILERVILLE
PENN CENTRAL R.R.
EAST HADDAM
GOODSPEEDS LANDING
EAST HADDAM BRIDGE
TYLERVILLE
EDDY ROCK SHOAL
RICH ID
LONG ID
EDDY ROCK LT
15' CHANNEL
CHAPMAN POND
WATERHOUSE POND
WHALEBONE CREEK RANGE LTS
MATCH LINE SHEET NO 1
N
Figure B-6
CONNECTICUT RIVER
BELOW HARTFORD, CONN.
30 SEPTEMBER 1970
IN 7 SHEETS
SCALE IN FEET
SHEET NO 3
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.



CORPS OF ENGINEERS
U S ARMY
133
1
LOCATION MAP
HARTFORD
CONNECTICUT RIVER
NEW LONDON
LONG ISLAND SOUND
LAND DISPOSAL (1976)
15' CHANNEL
CALVES ISLAND BAR
LORD COVE
LAND DISP (1976)
POTASH BAR
CHESTER ROCK LT
DEEP RIVER
MATCH LINE SHEET NO 3
BROCKWAY
LAND DISPOSAL (1976)
BROCKWAY BAR
FOR EIGHT MILE RIVER AREA SEE MAP NO 133/2
HAMBURG COVE
LAND (1964 1975)
ESSEX SHOAL
NORTH COVE
SOUTH COVE
ESSEX
FOR ESSEX SEE MAP 133
11' CHANNEL
SAYBROOK SHOAL
ANCHORAGE
6' ANCHORAGE
SOUTH COVE
FENWICK
SAYBROOK OUTER BAR
OLD LYME
BLACK RIVER
SECTION OF SAYBROOK WEST JETTY
SECTION OF SAYBROOK EAST JETTY
CONNECTICUT RIVER
BELOW HARTFORD CONN
30 SEPTEMBER 1976
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS

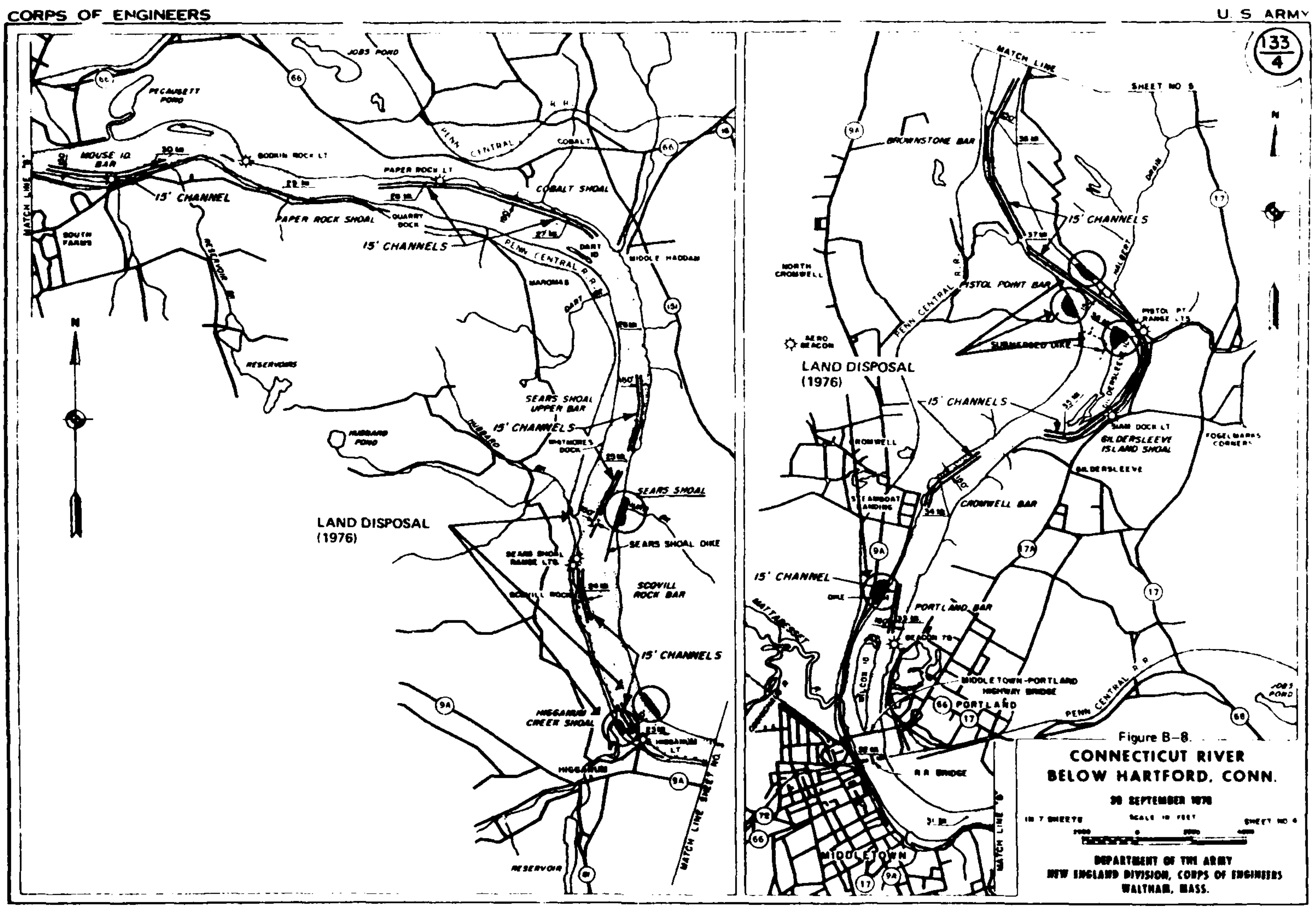


Figure B-8.

CONNECTICUT RIVER
BELOW HARTFORD, CONN.

30 SEPTEMBER 1970

IN 7 SHEETS — SCALE IN FEET — SHEET NO 4

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

CORPS F ENGINEERS

U. S. ARMY

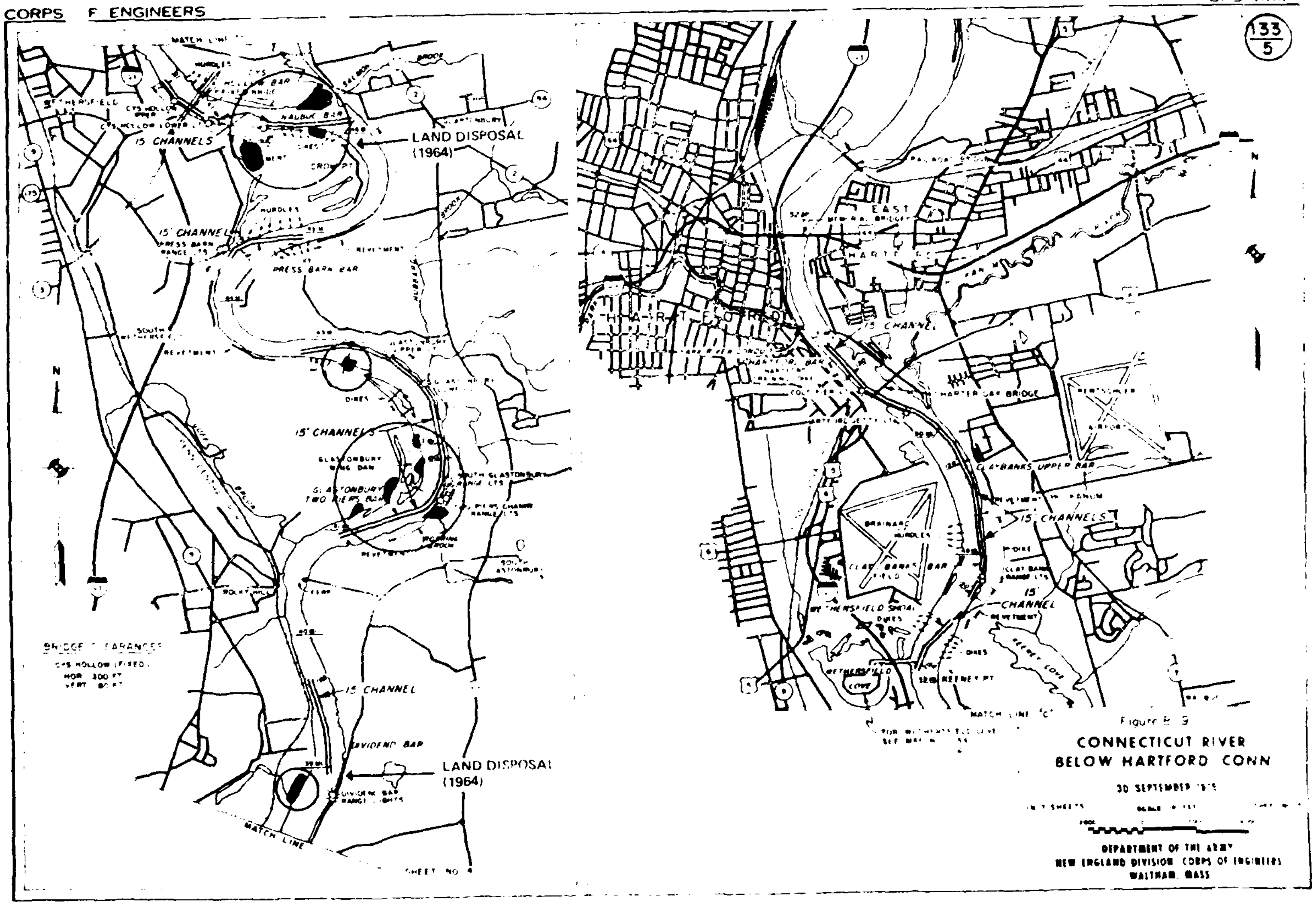


Figure B-9

CONNECTICUT RIVER
BELOW HARTFORD CONN

30 SEPTEMBER 1975

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS

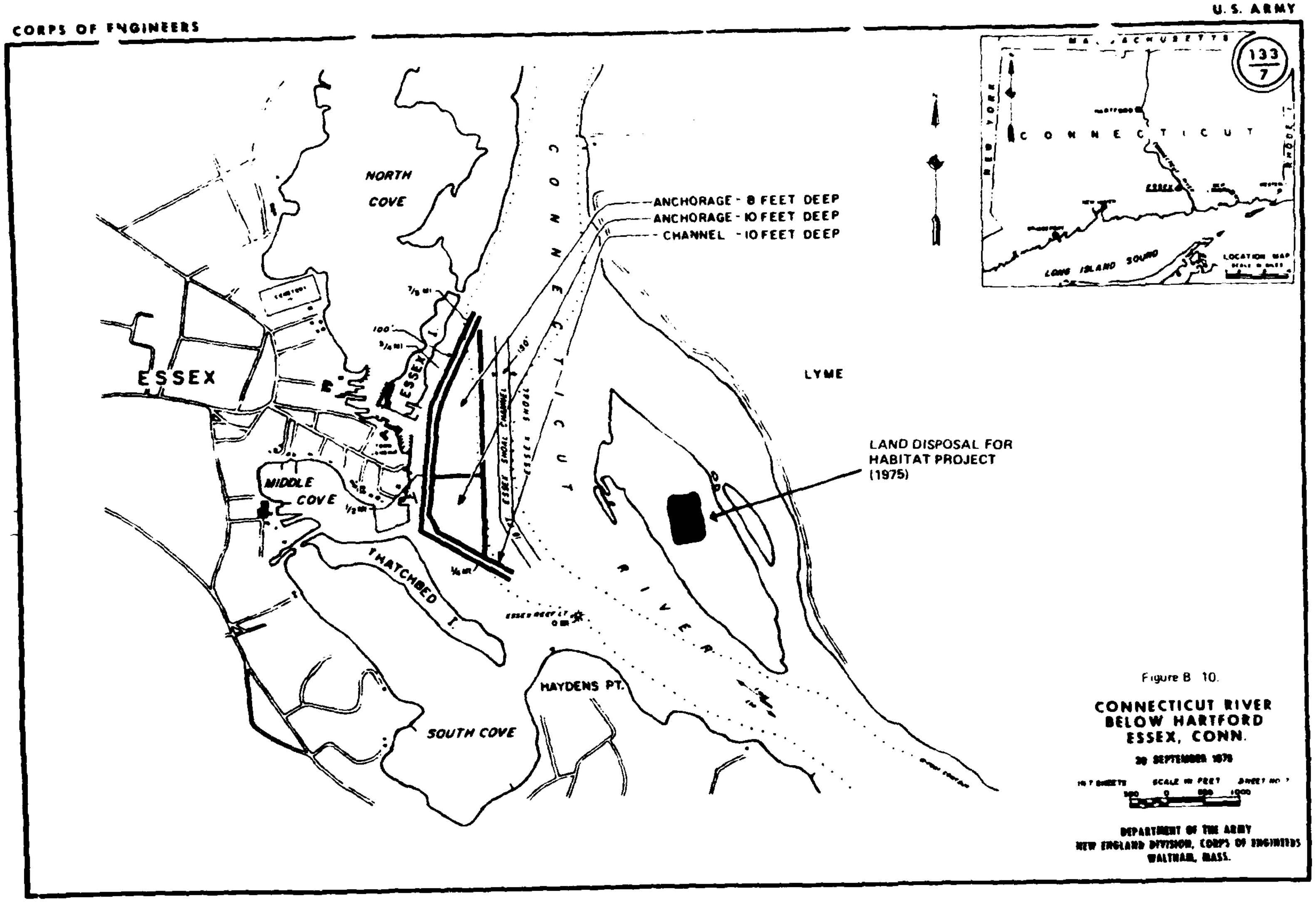


Figure B 10.

CONNECTICUT RIVER
BELOW HARTFORD
ESSEX, CONN.

APPENDIX C

OTHER DREDGING PROJECTS UNDER FEDERAL PERMIT - 1968 TO 1977

Table C-1 is an inventory of dredging/disposal projects done in Connecticut under Federal permit for the 10-year period 1968 to 1977. Table C-2 is a summary of the inventory, by year and U.S. Geological Survey quadrangle. The yearly amounts dredged in each coastal area are plotted in Figures C-1, C-2, and C-3.

To obtain the permits data, the NED office in Waltham was visited between May 15 and May 22, 1978. In the Regulatory Division, Permits Branch, a microfilmed file of permits, listing each permit according to USGS quadrangle, was examined. These cards contain dredging as well as other permits under the jurisdiction of the Corps of Engineers. In most cases, the stored information included the permitted quantity as well as the disposal method authorized. However, for those that did not, the full size file folders had to be consulted using the permit numbers as a guide. Unfortunately, dredging permit files before 1968 had been destroyed, making the search for quantity data or disposal method fruitless for projects prior to that date.

Since complete data was only available from 1968 onward, the data was compiled for the period 1968 through 1977. The microfilm file did not contain any data for 1978.

It must be noted that the permit quantity data are not as reliable as it might seem. There is no simple way to determine how much of the permitted work was done and how much material was actually dredged. The permitted yardage has to be taken as the best surrogate for the actual amount dredged and disposed.

As noted, there were no full-size files pertaining to dredging permits before 1968. The cards in the microfilm file exist for periods well before that, but only a small portion of the cards give the quantity or disposal method, and an even smaller percentage give both. To obtain reliable data before that time from the files at the Waltham office is not possible.

TABLE C-1

INVENTORY OF DREDGING/DISPOSAL IN CONNECTICUT UNDER FEDERAL PERMIT (1968-1977)

CONNECTICUT COASTAL AREA	USGS QUADRANGLE	PERMIT YEAR AND NUMBER	PROJECT LOCATION (WATERWAY)	VOLUME (CY)	DISPOSAL METHOD
Western Coastal Area (including Housatonic River)	Glenville	70-221	Greenwich Hbr.	1,400	Open water
		-284		465	Open water
	Stamford	77-034	Greenwich Cove	120	Land
		75-173		15,000	Open water
		74-103	Mianus River	1,600	Open water
		72-181		4,700	Open water
		71-207		20,000	Open water
		69-222		32,400	Open water
		72-212	Coscob Hbr.	53,000	Open water
		70-174		2,800	Open water
		76-485	Stamford Hbr.	590	Land
		70-292		3,200	Open water
		70-077		160	Land
		70-076		8,000	Open water
		68-344		110	Land
		69-013	Westcott Cove	2,000	Land
		76-234	Strickland Brook	2,150	-
		72-148	Long Island Sound	3,500	Land
		71-078	Little Cove	21,000	Land
		71-015	Cove Hbr.	4,500	Open water
		70-111	Chimney Corner	3,000	Land

TABLE C-1 (CONT.)

CONNECTICUT COASTAL AREA	USGS QUADRANGLE	PERMIT YEAR AND NUMBER	PROJECT LOCATION (WATERWAY)	VOLUME (CY)	DISPOSAL METHOD
Western	Norwalk South	75-005	Fivemile River	2,100	Open water
		70-036		1,000	Land
		69-095		500	Open water
		-073		650	Open water
		-069		1,200	Open water
		-070		375	Open water
		76-336	Charles Creek	3,200	Land
		75-278		4,000	Land
		73-302		4,000	Land
		72-033	Norwalk Hbr.	6,000	Open water
		71-064		3,000	Open water
		69-323		2,000	Open water
		77-158	Norwalk River	900	Land
		75-006		3,600	Open water
		74-113		3,200	Open water
		69-227		1,500	Land
		73-032	Darien River	6,000	Open water
		69-012		1,500	Open water
		76-260	Saugatuck River	4,000	Open water
		69-293		1,400	Open water
		73-056	Long Island Sound	3,000	Land
		72-266		9,100	Land
		70-118	Sheffield Hbr.	2,500	Open water
		-117		1,100	Open water
		70-116	Wilson Cove	850	Open water
		-107		15,000	Open water
		77-249	Goodwives River	1,600	Land
		70-230	E. Norwalk Ch.	3,000	Open water

TABLE C-1 (CONT.)

CONNECTICUT COASTAL AREA	USGS QUADRANGLE	PERMIT YEAR AND NUMBER	PROJECT LOCATION (WATERWAY)	VOLUME (CY)	DISPOSAL METHOD
Western	Westport	70-267	Mill River	8,000	Open water
		69-062		450	Open water
		77-057	Saugatuck River	2,000	Land
		69-083		50	Open water
		69-238	Long Island Sound	30,000	Open water
	Bridgeport	76-345	Johnson's River	4,500	Land
		75-44	Pequonnock River	7,000	Open water
		71-254		3,000	Land
		70-207	Cedar Creek	12,500	Open water
		70-100	Ash Creek	90,000	Land
		68-199	Black Rock Hbr.	10,000	Open water
		71-014	Bridgeport Hbr.	4,000	Open water
		70-034		10,000	Open water
		68-257		10,000	Open water
		70-191	Burr Creek	20,000	Open water
	Milford	77-128	Housatonic River	300	Land
		-165		17,040	Land
		75-320		20,000	Open water
		-137		150	Land
		73-351		15,000	Land
		70-271		27,000	Open water
		-133		22,000	Open water
		69-245		12,000	Land
		-067		11,000	Land

TABLE C-1 (CONT.)

CONNECTICUT COASTAL AREA	USGS QUADRANGLE	PERMIT YEAR AND NUMBER	PROJECT LOCATION (WATERWAY)	VOLUME (CY)	DISPOSAL METHOD
Western	Milford	75-135	Milford Hbr.	200	Land
		69-085		1,200	Open water
Central Coastal Area (including Connecticut River)	New Haven	77-181	New Haven Hbr.	6,000	Land
		-241		650	Land
		-467		15,000	Land
		76-261		26,234	Open water
		74-043		12,000	Open water
		-033		20,000	Open water
		73-217		320,000	Open water
		70-072		10,000	Open water
		69-077		4,000	Open water
		-078		60,000	Land
		-200		24,000	Open water
		71-019	West River	6,000	Open water
		70-113		20,000	Open water
		77-132	Quinnipiac River	100	Land
		-272		800	Land
		-416		12,000	Land
		70-265		1,200	Open water
		72-215	Morris Cove	800	Land
	Branford	77-046	Branford River	27,000	Land
		-116		2,500	Land
		74-224		14,000	Land
		73-110		6,200	Open water
		72-113		10,300	Land
		71-063		6,000	Land
		69-096		5,000	Land
		68-106		9,000	Open water
		69-284	Stony Creek Hbr.	35,200	Open water

TABLE C-1 (CONT.)

CONNECTICUT COASTAL AREA	USGS QUAD-RANGLE	PERMIT YEAR AND NUMBER	PROJECT LOCATION (WATERWAY)	VOLUME (CY)	DISPOSAL METHOD
Central	Branford	77-468	Long Island Sound	10,000	Open water
		76-258*		5,000	Open water
		72-081		1,200	Open water
		71-028		15,000	Open water
		69-065		1,600	Open water
	Guilford	76-535	West River	1,333	Land
		75-317		18,000	Land
		68-127		20,000	Land
		74-017	Guilford Hbr.	69,000	Open water
		74-020	Sluice Creek	8,900	Open water
		75-226	Faulkner Island	1,000	In water
		70-029	Neck River	2,400	Land
	Clinton	77-177	Clinton Hbr.	32,000	Land
		74-079		2,350	Land
		-058		10,100	Land
		-052		5,700	Land
		72-045		78,200	Land
		70-114		265,000	Land
		-078		2,500	Land
		69-198		200	Land
		-136		800	Land
		-008		4,800	Land
		75-542	Hammonasset River	2,800	Land
		-046		4,800	Land
		69-166		20,000	Land
		70-098	Indian River	1,000	Land

*Permit for 2,500-5,000 cubic yards per year for 10 years.

TABLE C-1 (CONT.)

CONNEC-TICUT COASTAL AREA	USGS QUAD-RANGLE	PERMIT YEAR AND NUMBER	PROJECT LOCATION (WATERWAY)	VOLUME (CY)	DISPOSAL METHOD
Central	Essex	76-061	North Cove	18,000	Land
		75-051		3,200	Land
		73-242		500	Land
		71-106		12,000	Land
		69-308		6,000	Open water
		77-395	Patchogue River	1,600	Land
		76-071		12,000	Land
		75-205		1,500	Land
		-015		1,000	Land
		74-045		125	Land
		71-033		41,000	Land
		70-172		160,000	Land
		-012		3,000	Land
		69-281		35,000	Land
		-093		1,500	Land
		-084		4,000	Land
		-066		18,000	Land
		68-358		1,500	Land
		76-586	Menunketesuck River	950	Land
		73-027		2,000	Land
		70-042		45,000	Land
		68-363		2,700	Land
		76-295	Connecticut River	2,200	Land
		-112		3,560	Land
		71-183		400	Land
		70-024		24,000	Land
	Old Lyme	77-139	Connecticut River	2,400	Land
		-155		5,000	Open water
		76-389		220	Land
		75-288		2,500	Land
		-078		10,000	Land
		73-255		230,000	Land

TABLE C-1 (CONT.)

CONNECTICUT COASTAL AREA	USGS QUADRANGLE	PERMIT YEAR AND NUMBER	PROJECT LOCATION (WATERWAY)	VOLUME (CY)	DISPOSAL METHOD
Central	Old Lyme	73-06A	Connecticut River	12,000	Land
		72-074		2,000	Land
		-044		3,000	Land
		71-057		4,000	Land
		70-263		30	Land
		-175		4,000	Land
		70-063		3,000	Open water
		-046		11,000	Land
		-028		4,000	Land
		69-311		4,000	Open water
		-295		12,000	Land
		-266		230,000	Land
		-186		3,000	Land
		-181		5,000	Open water
		68-322		10,000	Land
	Deep River	76-228	Connecticut River	6,000	Land
		70-229		310	Land
		-183		14,000	Land
		69-135		450	Land
		72-048	Salmon River	700	Land
		71-018	Chester Creek	13,000	Land
	Middletown	76-508	Connecticut River	500	Land
		75-080		1,000	Land
		-063		150	Land
	Hartford (North & South)	71-124	Connecticut River	1,350	Land
		69-179		14,000	Land

TABLE C-1 (CONT.)

CONNECTICUT COASTAL AREA	USGS QUADRANGLE	PERMIT YEAR AND NUMBER	PROJECT LOCATION (WATERWAY)	VOLUME (CY)	DISPOSAL METHOD
Central	Glastonbury	70-202	Connecticut River	11,000	Land
Eastern Coastal Area (including Thames River)	Niantic	69-235	Niantic River	3,000	Land
		77-325	Niantic Bay	1,000	Land
		76-391		3,000	Land
		75-291		800	Land
		-128		40,000	Open water
		74-067		1,050	Land
		70-244		40,000	Open water
		-120		35,000	Open water
	New London	77-110	Thames River	244,000	Open water
		-235		20,000	Open water
		-414		75	Land
		76-259		18,700	Open water
		75-023		7,500	Land
		74-063*		2,800,000	Open water
		-008		20,000	Land
		-083		43,000	Open water
		73-104		3,000	Land
		72-132		65,000	-
		70-287		3,000	Open water
		-135		5,000	Open water
		-057		160,000	Open water
		-006		3,000	Open water
		69-194		29,000	Open water
		73-314	New London Hbr.	14,000	Land
		69-184		16,000	Open water
		77-066	Pine Island Bay	8,000	Land
		74-163		17,000	Open water
		72-071		2,300	Open water
		77-446	Shaws Cove	1,000	Land
		73-205		250	Land

*Improvement project at U.S. Navy Submarine Base.

TABLE C-1 (CONT.)

CONNECTICUT COASTAL AREA	USGS QUAD-RANGLE	PERMIT YEAR AND NUMBER	PROJECT LOCATION (WATERWAY)	VOLUME (CY)	DISPOSAL METHOD
Eastern	New London	77-108	Palmer Cove	5,000	Land
		71-214	Mumford Cove	2,500	Open water
		76-076	Silver Eel Channel	1,200	Land
		72-211	Winthrop Cove	41,000	Land
		69-185	Long Island Sound	3,000	Open water
	Uncasville	75-033	Thames River	9,000	Open water
		72-228		3,500	Land
		70-092		160,000	Open water
		68-249		11,000	Open water
	Norwich	75-013	Thames River	6,000	Land
	Mystic	77-001	Mystic Hbr.	1,275	Land
		76-106		40	Land
		69-247		3,700	Open water
		-167		3,000	Open water
		77-085	Mystic River	5,200	Open water
		-200		180	Land
		-299		52	Land
		75-319		750	Land
		-149		3,500	Land
		73-288		14,500	Open water
		-146		5,000	Land
		70-276		4,000	Open water
		69-126		3,000	Open water
		68-351		11,000	Land
		74-198	West Cove	600	Land
		70-257		80,000	Open water

TABLE C-1 (CONT.)

CONNECTICUT COASTAL AREA	USGS QUAD-RANGLE	PERMIT YEAR AND NUMBER	PROJECT LOCATION (WATERWAY)	VOLUME (CY)	DISPOSAL METHOD
Eastern	Mystic	69-300	Stonington Hbr.	5,000	Land
		73-170	Williams Cove	120	Land
		73-014	Lower Narragansett Bay	100	Land
		72-169	Wequet. River	3,000	Land

TABLE C-2

TABULATION OF DREDGING/DISPOSAL IN CONNECTICUT COASTAL AREAS UNDER FEDERAL PERMIT, BY YEAR AND USGS QUADRANGLE (1968-1977) (CUBIC YARDS x 1,000)

CONNECTICUT COASTAL AREA	USGS QUADRANGLE	YEAR AND PERMITTED VOLUME 1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	TOTALS[a]
Western Coastal Area (including Housatonic River)	Glenville	-	-	1.9	-	-	-	-	-	-	-	1.9
	Stamford	0.1	34.4	17.2	45.5	61.2	-	1.6	15.0	2.7	0.1	177.8
	Norwalk So.	-	9.1	23.5	3.0	15.1	13.0	3.2	9.7	7.2	2.5	86.3
	Westport	-	30.5	8.0	-	-	-	-	-	-	2.0	40.5
	Bridgeport	20.0	-	132.5	7.0	-	-	-	7.0	4.5	-	171.0
	Milford	-	24.2	49.0	-	-	15.0	-	20.4	-	17.3	125.9
	Ansonia	-	-	-	-	-	-	-	-	-	60.0	60.0
TOTAL WESTERN[a]		20.1	98.2	232.1	55.5	76.3	28.0	4.8	52.1	14.4	81.9	663.4
Average annual volume 1968-1977 = 66,000 cubic yards												
Central Coastal Area (including Connecticut River)	New Haven	-	88.0	31.2	6.0	0.8	320.0	32.0	-	26.2	34.6	538.8
	Branford	9.0	41.8	-	21.0	11.5	6.2	14.0	-	5.0	39.5	148.0
	Guilford	20.0	-	2.4	-	-	-	77.9	19.0	1.3	-	120.6
	Clinton	-	25.8	268.5	-	78.2	-	18.2	7.6	-	32.0	430.3
	Essex	4.2	64.5	232.0	53.4	-	2.5	0.1	5.7	36.7	1.6	400.7
	Old Lyme	10.0	254.0	22.0	4.0	5.0	242.0	-	12.5	0.2	7.4	557.1
	Deep River	-	0.5	14.3	13.0	0.7	-	-	-	6.0	-	34.5
	Middletown	-	-	-	-	-	-	-	1.2	0.5	-	1.7
	Hartford N/S	-	14.0	-	1.4	-	-	-	-	-	-	15.4
	Glastonbury	-	-	11.0	-	-	-	-	-	-	-	11.0
TOTAL CENTRAL[a]		43.2	488.6	581.4	98.8	96.2	570.7	142.2	46.0	75.9	115.1	2,258.1
Average annual volume 1968-1977 = 226,000 cubic yards												
Eastern Coastal Area (including Thames River)	Niantic	-	3.0	75.0	-	-	-	1.1	40.8	3.0	1.0	123.9
	New London	-	48.0	171.0	2.5	108.3	3.3	2,880.0	7.5	19.9	278.1	3,518.6
	Uncasville	11.0	-	160.0	-	3.5	-	-	9.0	-	-	183.5
	Norwich	-	-	-	-	-	-	-	6.0	-	-	6.0
	Mystic	11.0	14.7	84.0	-	3.0	19.7	0.6	4.3	-	6.7	144.0
TOTAL EASTERN[a]		22.0	65.7	490.0	2.5	115.0	23.0	2,88[illegible]0 (2.0)[b]	67.6	23.0	285.8	3,976.5 (1,096.5)[b]
Average annual volume 1968-1977 = 398,000 cubic yards (110,000 cubic yards)												

[a]Totals have been rounded off.
[b]Excluding 1974 New London improvement project by U.S. Navy.

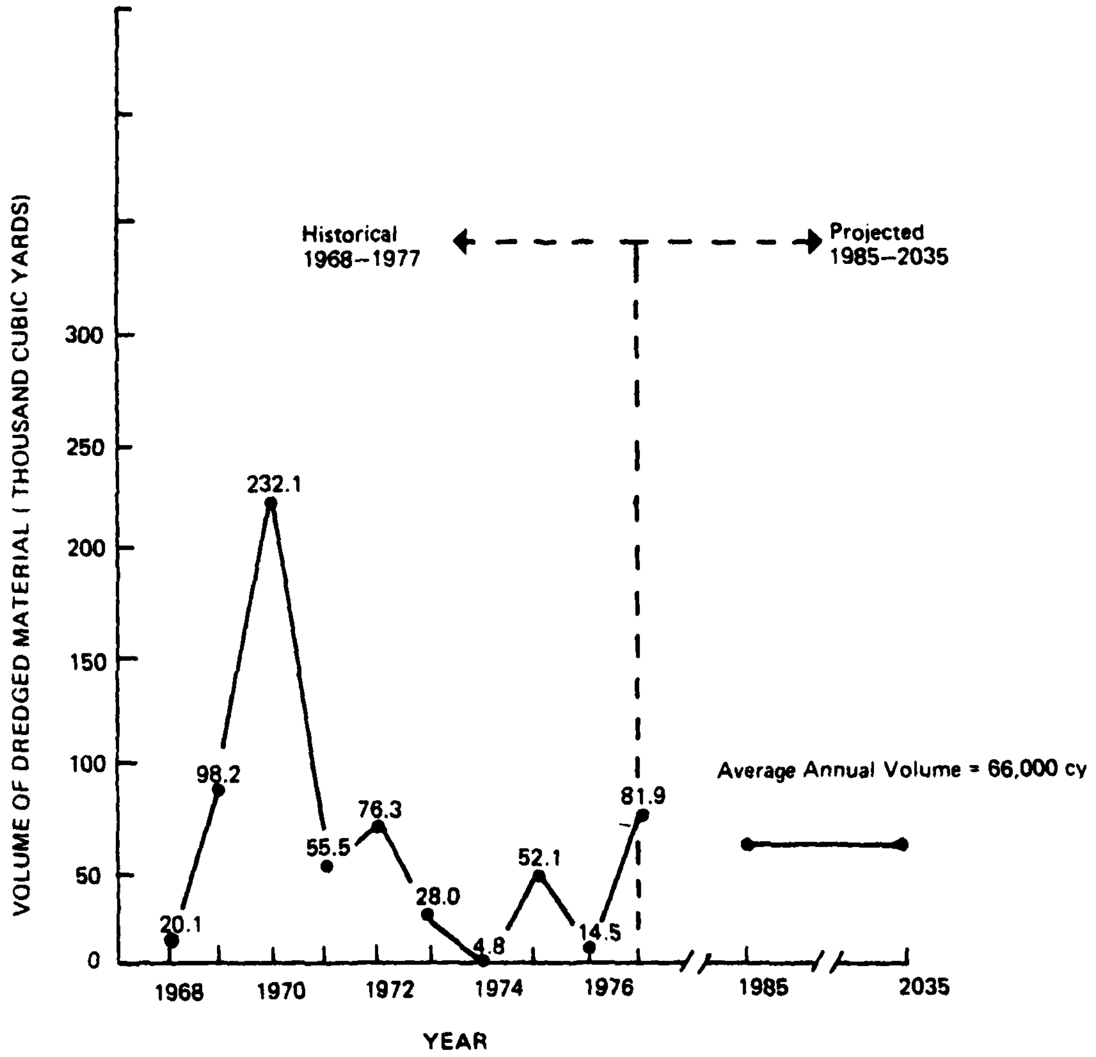


Figure C – 1. Western coastal area: dredging/disposal in the Connecticut under Federal permit.

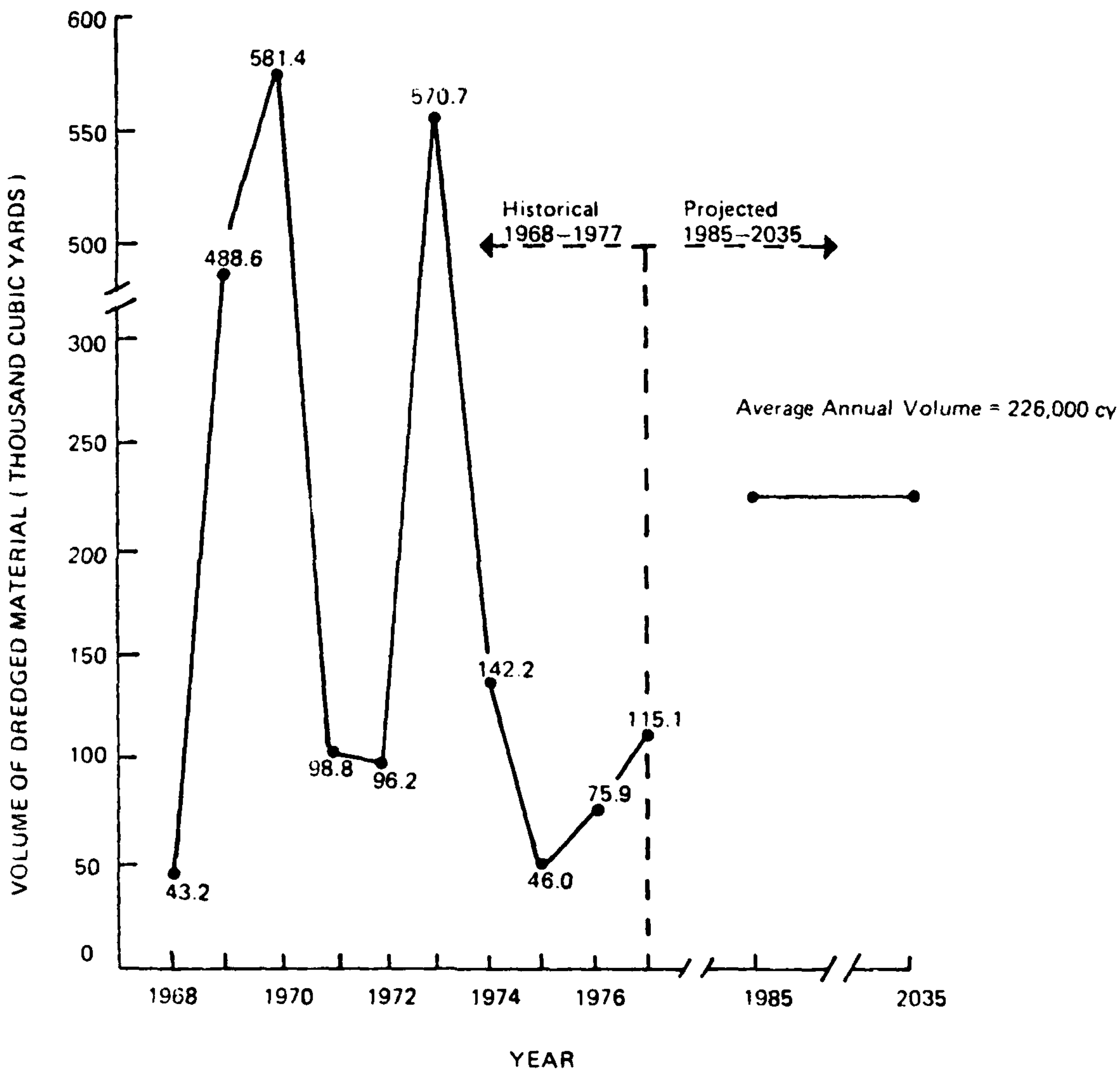


Figure C –2. Central coastal area: dredging/disposal in Connecticut under Federal permit.

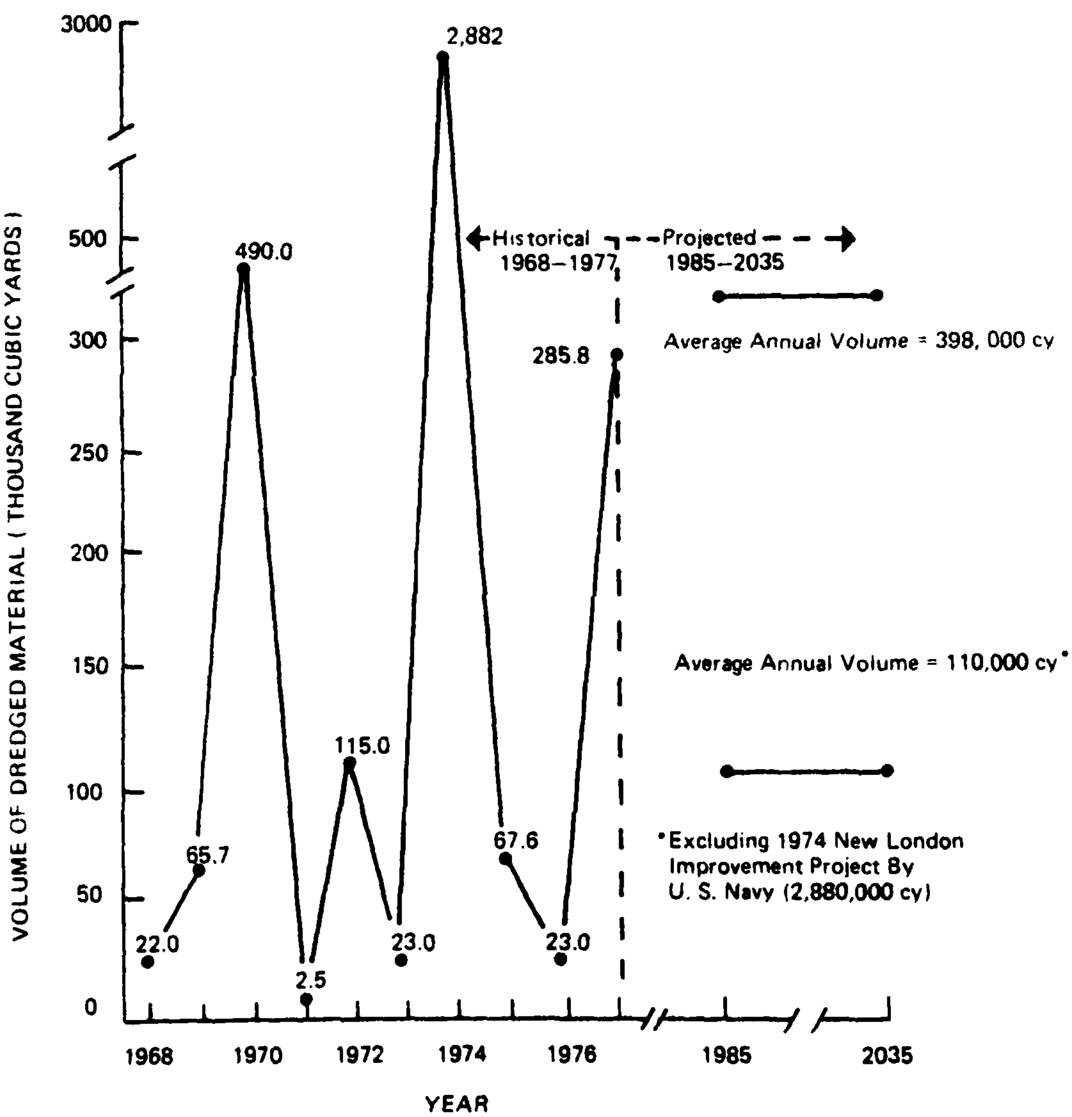


Figure C – 3. Eastern coastal area: dredging/disposal in Connecticut under Federal permit.

APPENDIX D

TECHNICAL APPENDIX

PROJECT NO. 8006 | SASAKI ASSOCIATES 64 PLEASANT STREET WATERTOWN, MA 02172 | SHEET NO. 1 OF 12 DATE Oct. 1978 BY JPJ RTW

TITLE Army Corps L.I.S. Dredge

DESIGN ASSUMPTIONS FOR ESTIMATING COFFERDAMS & DIKE WALLS

Dredged material: unit weight 75 lb/ft³ (dry), 90 lb/ft³ (wet). For all wall sizing, material is assumed wet (worst condition). Dredged material assumed to have no structural value for dike construction, except for low, on-shore dikes used to complete circumference of shoreline structures.

Long Island Sound: bottom is medium compact fine to medium sand, silty or clayey medium to coarse sand. Bearing capacity taken as 5000 lb/ft² ±. (1)

No rock stratum is available.

Cofferdams will be filled with free-draining material. unit weight = 100 lb/ft³ (dry), 36 lb/ft³ (buoyant)

Dikes will be solid rock with a liner. Crown width of 8 feet allows 3 rocks across top. Sideslopes are 1 to 1½. Unit weight of dike rocks = 90 lb/ft³.

DESIGN REFERENCES:

SHEET STEEL COFFERDAMS — Bethlehem Steel Sheet Piling Catalog 2620-B, Bethlehem Steel Corp.; USS Steel Sheet Piling Design Manual, United States Steel; USS Steel Sheet Piling Handbook, United States Steel; USS Steel Sheet Piling, Design Extracts from Former Catalogs.

DIKES — Dept. of the Army, Engineers Manual EM 1110-2-2904, Engineering & Design of Breakwaters and Jetties.

(1) Dept. of the Navy Design Manual NAVFAC DM-7, Table 11-1.

PLANNING/ARCHITECTURE/LANDSCAPE ARCHITECTURE/CIVIL ENGINEERING/ENVIRONMENTAL SERVICES

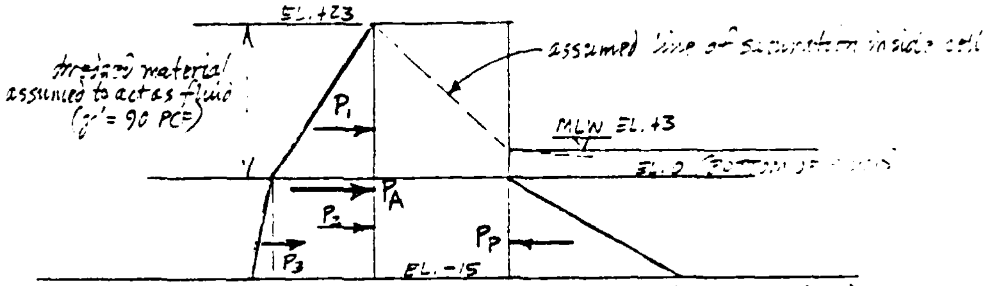
SASAKI ASSOCIATES
64 PLEASANT STREET
WATERTOWN, MA 02172

PROJECT NO ______
TITLE Army Corps L.I.S. Dredge

SHEET NO ______ DATE ______ BY ______

SHORELINE COFFERDAM

Height above bottom = 23'
Assume penetration of $\frac{2}{3}$ (Height); say 15'
Neglect MLW moment



foundation soil: assume γ = 100 PCF (dry), γ' = 36 PCF (wet)
$K_a = 0.33$, $K_p = 3.0$

ACTIVE PRESSURE:

$P_1 = \frac{1}{2}(23')^2(90\ PCF) = 23{,}805\#^*$ $\qquad h_1 = 15 + \frac{23}{3} = 22.67'$

$P_2 = (23')(90\ PCF)(15') = 31{,}050\#$ $\qquad h_2 = 15/2 = 7.5'$

$P_3 = \frac{1}{2}(15')^2(36\ PCF)(0.33) = 1336\#$ $\qquad h_3 = 15/3 = 5.0'$

$P_A = \Sigma P = 56{,}191\#$ $\qquad H_A = \frac{\Sigma Ph}{P_A} = 13.87'$

PASSIVE PRESSURE:

$P_P = \frac{1}{2}(15^2)(36\ PCF)(3.0) = 12{,}150\#$ $\qquad H_P = 15/3 = 5.0'$

NET OVERTURNING MOMENT:

$M = P_A H_A - P_P H_P = 779{,}217 - 60{,}750 = \underline{718{,}467\ \text{ft-lb}}$

DIAMETER OF CELL REQUIRED:

let w = avg. unit wt. of cell fill $= \frac{(100\ PCF)(10')_{dry} + (36\ PCF)(28')_{wet}}{38'} = 53\ PCF$

for rectangular cell, $x^2 = \frac{6M}{wh}$; for curved cell, $D = x/.85$

$D = \left(\sqrt{\frac{6M}{wh}}\right)/.85$ $\qquad D = \frac{\sqrt{\frac{(6)(718{,}467)}{(53)(38)}}}{.85} = 54.4'$ Diameter

*Per unit length (1 foot)

PLANNING/ARCHITECTURE/LANDSCAPE ARCHITECTURE/CIVIL ENGINEERING/ENVIRONMENTAL SERVICES

PROJECT NO. 2006 SASAKI ASSOCIATES
64 PLEASANT STREET
WATERTOWN, MA 02172

TITLE Army Corps L.I.S. Dredge

SHEET NO. 2 OF 12
DATE
BY

UNIT COSTS (SHORELINE COFFERDAM)

use 54.12' diameter cells (PS 32); 2.33 piles per foot

Steel weight = (40 PSF)(33')(2.33) = 4378 #/LF

Outboard surface to be coated:

cells are 59.7' ℄ to ℄; 51 piles & 2-90° Tees @ 1.25' = 66.25 ft² each cell

(66.25 ft² / 59.7 ft)(38 ft) = 42.2 SF/LF

Cell fill:

Area inside circular cell = 2300 ft²

" between circles = 534 ft²

Total area = 2834 ft²

$$\text{Volume} = \frac{(2834\ ft^2)(23')}{(59.7')(27\ ft^3/yd^3)} = 40.4\ CY/LF$$

SUMMARY:

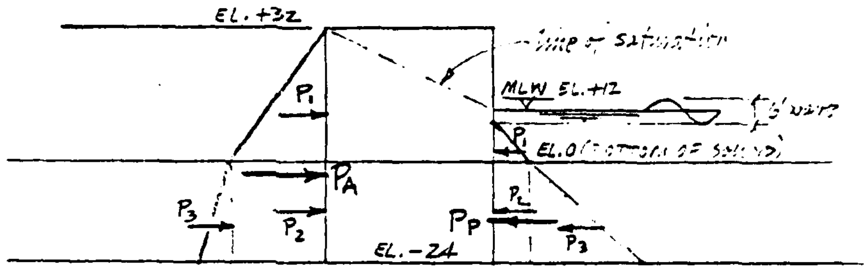
4378	lb steel sheet piles	@ $0.30	=	$1313.
42.2	SF coal tar epoxy	@ $1.00	=	42.
40.4	CY aggregate fill	@ $5.00	=	202.
				$1557
	(double for in-place cost)			x2
				$3114

say $3200/LF cost in place

PLANNING/ARCHITECTURE/LANDSCAPE ARCHITECTURE/CIVIL ENGINEERING/ENVIRONMENTAL SERVICES

NEARSHORE COFFERDAM

Height above bottom = 32'
Assume 24' penetration
MLW = EL. +12; Assume +9 to account for 3' waves



ACTIVE PRESSURE:

$P_1 = \frac{1}{2}(32')^2(90\ PCF) = 46,080\ \#$ $\quad h_1 = 24 + \frac{32}{3} = 34.67'$

$P_2 = (32')(90 PCF)(24') = 69,120\ \#$ $\quad h_2 = 24/2 = 12.0'$

$P_3 = \frac{1}{2}(24')^2(36\ PCF)(0.33) = 3421\ \#$ $\quad h_3 = 24/3 = 8.0'$

$P_A = \Sigma P = 118,621\ \#$ $\quad H_A = \frac{\Sigma Ph}{P_A} = 20.69'$

PASSIVE PRESSURE:

$P_1 = \frac{1}{2}(9^2)(64\ PCF) = 2592\ \#$ $\quad h_1 = 24 + 9/3 = 27.0'$

$P_2 = (9')(64\ PCF)(24') = 13,824\ \#$ $\quad h_2 = 24/2 = 12.0'$

$P_3 = \frac{1}{2}(24')^2(36\ PCF)(3.0) = 31,104\ \#$ $\quad h_3 = 24/3 = 8.0'$

$P_P = \Sigma P = 47,520\ \#$ $\quad H_P = \frac{\Sigma Ph}{P_P} = 10.20'$

NET OVERTURNING MOMENT:

$\curvearrowright M = P_A H_A - P_P H_P = 2,454,402 - 484,704 = 1,969,698$ ft-lb

DIAM. OF CELL REQUIRED:

avg. wt. of cell fill $w = [(100\ PCF)(10') + (36\ PCF)(46')] / 56' = 47$ PCF

$$D = \frac{\sqrt{\frac{(6)(1,969,698)}{(47)(56)}}}{.85} = 78.8' \text{ Diameter}$$

PLANNING/ARCHITECTURE/LANDSCAPE ARCHITECTURE/CIVIL ENGINEERING/ENVIRONMENTAL SERVICES

PROJECT NO. 8006

TITLE [illegible]

SASAKI ASSOCIATES
64 PLEASANT STREET
WATERTOWN, MA 02172

SHEET NO. 5 OF 16

DATE [illegible]

BY [illegible]

Unit Costs [illegible] Cofferdam

use 77.57' dia cells (PSX 32), 40° wyes, PS 32 [illegible]
cells are 90.22' ℄ to ℄; piles are 56' long

each cell: 176 - PSX 32 @ ~~44~~ lb/ft = 7744 #
54 - PS 32 @ 40 lb/ft = 2160 #
4 - 40° Wyes @ 38 lb/ft = 152 #
10,056 # } per vertical foot (one cell)

Steel Weight: $\frac{(10,056)(56)}{90.22}$ = 6242 #/LF

Surface to be coated:
57 - PSX 32 @ 16½" wide = 78.38 SF
27 - PS 32 @ 15" wide = 33.75 SF } per vertical foot (one cell)
112.13 SF

$\frac{(112.13)(56)}{90.22}$ = 69.6 SF/LF

Cell Fill:
Area inside circle = 4727 SF
" between circles = 1047 SF
Total area = 5774 SF

Volume = $\frac{(5774\ ft^2)(32')}{(90.22')(27\ ft^3/yd^3)}$ = 75.9 CY/LF

SUMMARY:

6242 # Steel piles @ \$0.30 = \$ 1873.
69.6 SF coal tar epoxy @ \$1.00 = \$ 70.
75.9 CY aggregate fill @ \$5.00 = \$ 380.

\$ 2323
(double for in-place cost) × 2

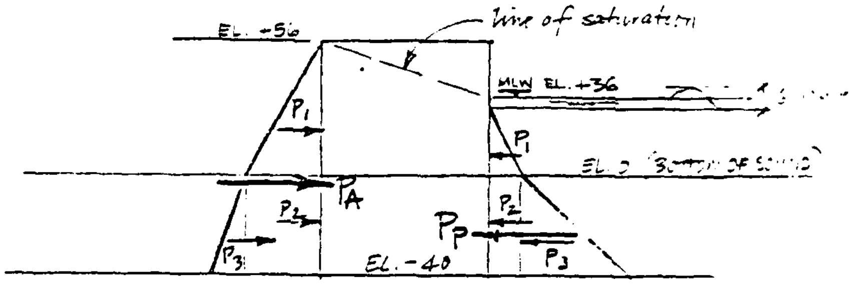
\$ 4646

say \$ 4700 /LF cost in place

PLANNING/ARCHITECTURE/LANDSCAPE ARCHITECTURE/CIVIL ENGINEERING/ENVIRONMENTAL SERVICES

OFFSHORE COFFERDAM

Height above bottom = 56'
Assume 40' penetration
MLW = EL. +36; Assume +33 to allow for [illegible]



ACTIVE PRESSURE:

$P_1 = \frac{1}{2}(56')^2(90\ PCF) = 141,120\ \#$ $\quad h_1 = 40 - \frac{56}{3} = 53.67'$

$P_2 = (56')(90\ PCF)(40') = 201,600\ \#$ $\quad h_2 = 40/2 = 20.0'$

$P_3 = \frac{1}{2}(40')^2(36\ PCF)(0.33) = 9,504\ \#$ $\quad h_3 = 40/3 = 13.33'$

$P_A = \Sigma P = 352,224\ \#$ $\quad H_A = \frac{\Sigma Ph}{P_A} = 35.31'$

PASSIVE PRESSURE:

$P_1 = \frac{1}{2}(33')^2(64\ PCF) = 34,848\ \#$ $\quad h_1 = 33/3 = 11.0'$

$P_2 = (33')(64\ PCF)(40') = 84,480\ \#$ $\quad h_2 = 40/2 = 20.0'$

$P_3 = \frac{1}{2}(40')^2(36\ PCF)(3.0) = 86,400\ \#$ $\quad h_3 = 40/3 = 13.33'$

$P_P = \Sigma P = 205,728\ \#$ $\quad H_P = \frac{\Sigma Ph}{P_P} = 15.67'$

NET OVERTURNING MOMENT:

$M = P_A H_A - P_P H_P = 12,438,199 - 3,224,640 = 9,213,559$ ft-lb

DIAM. OF CELL REQ'D:

avg. wt. of cell fill $\quad w = [(100\ PCF)(10') + (36\ PCF)(86')]/96' = 43\ PCF$

$$D = \frac{\sqrt{\frac{(6)(9,213,559)}{(43)(96)}}}{.85} = \underline{136'\ \text{diameter}}$$

PROJECT NO ____ **SASAKI ASSOCIATES** 64 PLEASANT STREET WATERTOWN, MA 02172

TITLE ____ DATE ____ BY ____ SHEET NO ___ OF 16

$$\frac{(16,080)(96)}{162.98} = 9472 \ \#/LF$$

152 — PSX32 @ 16½" wide = 209 SF

$$\frac{(209)(96)}{162.98} = 123 \text{ SF}/LF$$

Cell Fill:

Area inside circle = 14,880 SF
" between circles = 3,564 SF
Total area = 18,444 SF

$$\text{Volume} = \frac{(18,444 \text{ ft}^2)(56')}{(162.98')(27 \text{ ft}^3/\text{yd}^3)} = 235 \text{ CY}/LF$$

SUMMARY:

9472 # Steel piles @ $.30 = $ 2842.
123 SF Coal Tar Epoxy @ $1.00 = $ 123.
235 CY Aggregate Fill @ $5.00 = $ 1175.

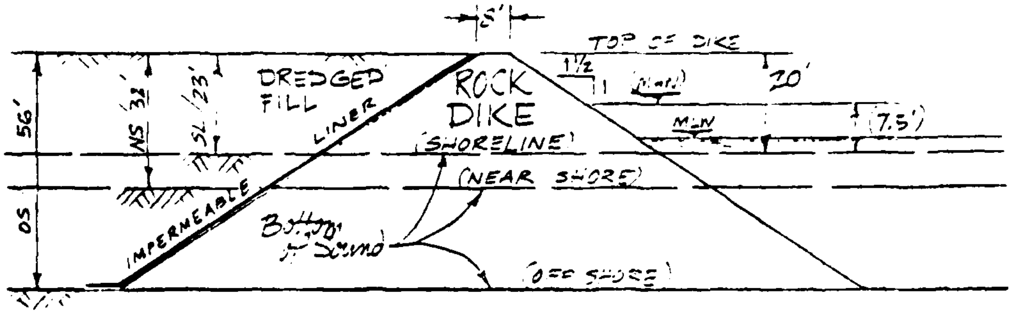
$ 4140
x2
(double for in-place cost) $ 8280

say $ 8300/LF cost in place

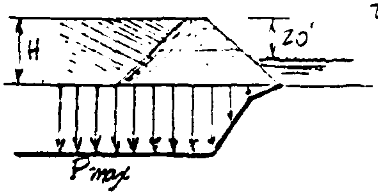
PLANNING/ARCHITECTURE/LANDSCAPE ARCHITECTURE/CIVIL ENGINEERING/ENVIRONMENTAL SERVICES

PROJECT NO. 8066
TITLE Army Corps L.I.S. Dredge
SASAKI ASSOCIATES
64 PLEASANT STREET
WATERTOWN, MA 02172
DATE Oct. 1978
BY
SHEET NO. OF

SHORELINE, NEARSHORE & OFFSHORE DIKES



SOIL BEARING PRESSURE



take unit wt. of fill = 90 #/ft³ above MLW
= 26 #/ft³ below MLW
unit wt. of dike = 90 #/ft³ above MLW
26 #/ft³ below MLW

$$P_{max} = (20')(90\ PCF) + (26\ PCF)(H - 20) = 1280 + 26H$$

P_{max} = 1878 #/ft² (shoreline)
2112 #/ft² (near shore)
2736 #/ft² (off shore)

PROJECT NO. 8006 SASAKI ASSOCIATES SHEET NO 2 OF 15

TITLE Army Corps L.I.S. Dredge 64 PLEASANT STREET DATE [illegible] 1978

WATERTOWN, MA 02172 BY JPI [illegible]

[illegible]

ROCK — [illegible]

Volume in CY $= \left(\frac{3}{2} H^2 + 8H\right) \div 27$
= 36.2 CY (shoreline),
66.4 CY (near shore),
190.8 CY (off shore) } per linear foot

LINER — inboard side

Area in SF $= \sqrt{(1.5)^2+1}\ H = 1.80\ H$ [illegible]
= 41.4 SF (shoreline),
= 57.6 SF (nearshore),
= 100.8 SF (offshore) } per linear foot

COSTS: \$25/ton for rock dumped inshore (90 #/CF)

$\frac{(90)(27)}{2000} \times 25 = \$30/CY$

\$30/Ton deeper = \$36/CY deeper

Liner — 6¢/ft² (mat'ls.); 12¢/ft² (installed)

SUMMARY:
(Consider only rock cost-in-place; liner ≤ 1% of total)

SHORELINE: 36.2 CY @ \$30 = \$1086/LF; say \$ 1,100/LF

NEARSHORE: 66.4 CY @ \$36 = \$2390/LF; say \$ 2400/LF

OFFSHORE: 190.8 CY @ \$36 = \$6,868/LF; say \$ 6,900/LF

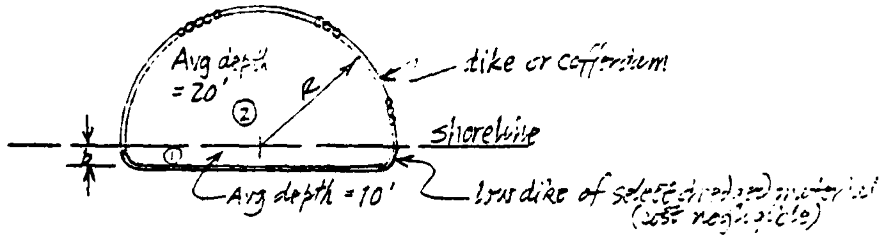
PLANNING/ARCHITECTURE/LANDSCAPE ARCHITECTURE/CIVIL ENGINEERING/ENVIRONMENTAL SERVICES

PROJECT NO. 6006 | SASAKI ASSOCIATES, 64 PLEASANT STREET, WATERTOWN, MA 02172 | SHEET NO 1 OF 1

TITLE Army Corps L.I.S. Dredge | DATE ... 1978 | BY PJS ...

CONTAINER SIZE REQ'D. FOR VARIOUS CAPACITIES

SHORELINE CONTAINER (R = equivalent inside radius in feet)



say b = 100 feet (restricted by geography)

$$V_1 = (10')(100')(2R) = 2000\,R$$
$$V_2 = \tfrac{1}{2}(20')\,\pi r^2 = 10\,\pi r^2$$

given V in cu.yd., the following equation may be solved for R:

$$\boxed{V = 1.164R^2 + 74.07R}$$

NEARSHORE CONTAINER

$$V = \frac{32\pi R^2}{27}; \quad \boxed{R = 0.5182\sqrt{V}} \quad (V \text{ in cu.yd.})$$

OFFSHORE CONTAINER

$$V = \frac{56\pi R^2}{27}; \quad \boxed{R = 0.3918\sqrt{V}} \quad (V \text{ in cu. yd})$$

PROJECT NO. 8006 | SASAKI ASSOCIATES | SHEET NO. 11 OF 16

64 PLEASANT STREET

WATERTOWN, MA 02172

TITLE Army Corps L.I.S. Dredge

DATE Oct. 1978

BY JPJ

	INSIDE RADIUS (feet)		
CAPACITY (millions of cu. yd.)	Shoreline	Nearshore	Offshore
12	3179	1795	1357
30	5045	[illegible]	2146
37	[illegible]	[illegible]	[illegible]
59	[illegible]	[illegible]	[illegible]

	FIRST COST PER FOOT OF WALL		
	SL	NS	OS
DIKE WALL	$1100	$2400	$6900
SHEET PILE COFFERDAM	$3200	$4700	$8300

PLANNING/ARCHITECTURE/LANDSCAPE ARCHITECTURE/CIVIL ENGINEERING/ENVIRONMENTAL SERVICES

CONTAINER SIZING (continued)

Given: R = inside radius of container (see sheet 10, 11)

inside diameter $ID = 2R$

cofferdam: nominal diameter $ND = ID + 0.85\ D_c$
(D_c = Diameter of cofferdam cells)

dike $ND = ID + \frac{3}{4}H + 4$

cofferdam outside diameter $OD = ID + 1.7\ D_c$

dike $OD = ID + \frac{9}{4}H + 8$

bottom area (shoreline sites) $= \left[\frac{1}{2}\pi\left(\frac{OD}{2}\right)^2 + 100\,(OD)\right] \div 43560$

$$= \frac{0.3927\,(OD^2) + 100\,(OD)}{43{,}560} \quad \text{(area in acres)}$$

bottom area (nearshore & offshore) $= \left[\pi\left(\frac{OD}{2}\right)^2\right] \div 43560$

$$= \frac{0.7854\,(OD)^2}{43{,}560}$$

wall length (shoreline) $= \frac{\pi\,(ND)}{2} = 1.5703\,(ND)$

wall length (nearshore & offshore) $= \pi\,(ND) = 3.1416\,(ND)$

~~total~~ container cost = (cost per foot)(wall length)

	CAPACITY (millions of cu. yds.)											
	12			30			37			59		
	SL	NS	OS	SL	NS	OS	SL	NS	OS	SL	NS	OS
ID (Coffer or Dike)	6358	3590	2714	10,090	5676	4292	11,212	6,304	4,766	14,176	7,960	6,020
ND (Coffer)	6404	3656	2831	10,136	5742	4409	11,258	6370	4883	14,222	8026	6137
ND (Dike)	6379	3618	2760	10,111	5704	4338	11,233	6332	4812	14,197	7988	6066
OD (Coffer)	6450	3722	2948	10,182	5808	4526	11,304	6436	5000	14,268	8092	6254
OD (Dike)	6418	3670	2848	10,150	5756	4426	11,272	6384	4900	14,236	8040	6154
A (Coffer)	390	250	157	958	608	369	1178	747	451	1868	1181	705
A (Dike)	386	243	146	952	597	353	1171	735	433	1860	1166	683
L (Coffer)	10,059	11,485	8894	15,922	18,039	13,851	17,684	20,012	15,340	23,340	25,214	19,280
L (Dike)	10,020	11,366	8671	15,883	17,920	13,628	17,645	19,893	15,117	22,301	25,095	19,057
First Cost (Coffer)	32.2	54.0	73.8	51.0	84.8	115.0	56.6	94.0	127.3	71.5	118.5	160.0
First Cost (Dike)	11.0	27.3	59.8	17.5	43.0	94.0	19.4	47.7	104.3	24.5	60.2	131.5

(Linear dimensions in feet, areas in acres, first costs in millions of dollars)

NOTE:

Whereas properly constructed dikes may be expected to remain in place indefinately, and liners of polypropylene and certain other materials likewise have an indefinate service life,(1) compared to an expected service life of 25 to 30 years for cofferdams of ASTM A690 steel protected with coal tar epoxy(2), and whereas the dike has a lower cost for all sizes and sites considered, the balance of this report will be confined to an analysis of dike wall alternatives.

TABLE: COST PER CU. YD. CAPACITY

CAPACITY (millions of cu. yd.)	SL	NS	OS
12	\$0.92	\$2.28	\$4.98 MOST EXPENSIVE
30	\$0.58	\$1.43	\$3.13
37	\$0.52	\$1.29	\$2.82
59	\$0.42 LEAST EXPENSIVE	\$1.02	\$2.23

(1) Discussion with AH Harris & Sons.
(2) Discussion with Carl Caskodon, US Steel.

VIABLE ALTERNATIVES

(Anticipated demand from Table 8, Dredged Material Projections, 1985-2035)

	CONNECTICUT COASTAL AREA		
Container Alternatives	WESTERN 12 MCY Req'd.	CENTRAL 37 MCY Req'd.	EASTERN 12 MCY Req'd
1	X	59 MCY Now	X
2	X	30 MCY Now, 30 MCY in 25 yrs.	X
3	12 MCY now	37 MCY now	12 MCY now
4	12 MCY now	12 MCY now, 12 MCY in 17 yrs., 12 MCY in 34 yrs.	12 MCY now

Present value factor:

$$PV = \frac{1}{(1+i)^n} \quad \text{where } i = \text{interest rate } (6\tfrac{7}{8}\%),\ n = \text{no. of years}$$

$PV = 1.0$ (First Year)

$PV = 0.327586$ (17 yrs.)

$PV = 0.193751$ (25 yrs)

$PV = 0.107313$ (34 yrs)

Present Worth = (First Cost from table, sheet 13)(present value factor PV)

PROJECT NO. 8006

TITLE Army Corps L.I.S. Dredge

SASAKI ASSOCIATES
64 PLEASANT STREET
WATERTOWN, MA 02172

SHEET NO. 15 OF 16

DATE Oct. 1978

BY JPJ RTW

REV. 12/15/78

PRESENT WORTH OF VIABLE ALTERNATIVES
(see preceding sheet)

Container Alternative	Location	Present Worth * (millions of dollars)
1	SL NS OS	24.5 60.2 131.5
2	SL NS OS	20.9 51.3 112.2
3	SL NS OS	41.4 102.3 224.0
4	SL NS OS	37.8 93.8 205.4

* First costs are from the last line of the table on sheet 13, for dike containers of the various capacities.

Example Calculation:

Container Alternative 2 for a nearshore island location:

$$\text{Present Worth} = \begin{pmatrix}\text{First}\\\text{Cost}\end{pmatrix}\begin{pmatrix}\text{Present Value}\\\text{factor for first}\\\text{year}\end{pmatrix} + \begin{pmatrix}\text{First}\\\text{Cost}\end{pmatrix}\begin{pmatrix}\text{Present Value}\\\text{factor for}\\\text{25 yrs.}\end{pmatrix}$$

$$\text{Present Worth} = (\$43\text{ million})(1.0) + (\$43\text{ million})(0.193751)$$

$$\text{Present Worth} = \$43\text{ million} + \$8.3\text{ million}$$

$$\underline{\text{Present Worth} = \$51.3\text{ million}}$$

PLANNING/ARCHITECTURE/LANDSCAPE ARCHITECTURE/CIVIL ENGINEERING/ENVIRONMENTAL SERVICES

SA

Sasaki Associates, Inc., 64 Pleasant Street, Watertown, Massachusetts 02172 · (617) 926-3300 Telex 92-2471

RE: Army U.S. Dredge - Sheet Pile Cell Cofferdams
SA #8006

MEMORANDUM: BY: R.T. Westcott DATE: 11 September 1978

TO: File

Telephone call to U.S. Steel (267-9292) in New Jersey. Left name and number.

On 11 September 1978 at 2:00 P.M., Carl Caskadon, U.S.S., called back. I described overall job requirements with him. He said he would send whatever design aids he had, and that I should use these to reach a preliminary design. Then I should call him back and he could tell me material costs. He said past experience has shown 2x material costs is a good rough extimate of in-place cost.

rek/8006

SA

Sasaki Associates, Inc., 64 Pleasant Street, Watertown, Massachusetts 02172 · (617) 926-3300 Telex 92-2471

RE: Army LIS Dredge - Sheet Pile Cell Cofferdams
SA #8006

MEMORANDUM: BY: R.T. Westcott DATE: 11 September 1978

TO: File

Telephone call to Bethlehem Steel - Prudential Center Boston - referred to New Jersey Central Office. Left name and number.

At 10:25 A.M. Dave Magee, Bethlehem Steel, called back. He said Bethlehem Steel is not making sheet cell piling anymore; but he will send what information about design he can find. He said U.S. Steel is the only manufacturer now making sheet cell piling.

rek/8006

SA

Sasaki Associates, Inc., 64 Pleasant Street, Watertown, Massachusetts 02172 · (617) 926-3300 Telex 92-2471

RE: Army LIS Dredge - Sheet Pile Cell Cofferdams
SA #8006

MEMORANDUM: BY: R.T. Westcott DATE: 15 September 1978

TO: File

Telephone call to U.S.S. in New Jersey, referred to Carl Caskadon, local representative at (201) 843-0411

From previous call on 11 September 1978, U.S.S. Steel Sheet Piling Design Manual and S.S.S. Steel Sheet Piling Handbook were sent to me. Based on my preliminary designs using these, I called Mr. Caskadon back to determine his estimate of construction costs, protective coatings, and anticipated useful life. He said steel should be their "Mariner" type, coated with coal tar epoxy to the mud-line on the exterior ocean side. Inside surfaces are protected from splash and starved of much oxygen. This system would have a life of 25-30 years. Material costs: 28½¢/lb., add more for fasteners (fasteners cost 40¢/lb. No. of connections is a factor). For my purpose figure 30¢/lb. overall material cost. Double for in-place cost. Firgure $1/sf for coating costs.

It may be necessary to excavate silt within the cell to prevent settlement of the fill and loss of shear strength. He could not give me an estimate of the cost of the cell fill. Fill with a good mixture of sand and gravel.

Mentioned piles come in 60' lengths; but that splices were not a problem as loads were radial.

rek/8006

SA

Sasaki Associates, Inc., 64 Pleasant Street, Watertown, Massachusetts 02172 · (617) 926-3300 Telex 92-2471

RE: Army LIS Dredge - Rock Dike Construction Costs
SA #8006

MEMORANDUM: BY: R.T. Westcott DATE: 19 September 1978

TO: File

Telephone call to Perini Construction Corporation, East Boston, 567-0028.

Referred to Main Framingham Office, 875-6171, the Chief Engineer of the Marine Division. Told to ask for Ricky Rex. Called immediately and discussed job concept with Mr. Rex. He told me in-place cost of rock bottomed - dumped at sea would be between $25-$30/ton, depending on depth. Higher figure for deeper regions. Cell fill would run about $5/cy material cost and about $10/cy in-place cost, for the sheet pile cellular cofferdams.

rek/8006

SA

Sasaki Associates, Inc., 64 Pleasant Street, Watertown, Massachusetts 02172 · (617) 926-3300 Telex 92-2471

RE: Army LIS Dredge - Rock Dikes
SA #8006

MEMORANDUM: BY: R.T. Westcott DATE: 19 September 1978

TO: File

Telephone call to Celanese Fibers Marketing Co. - makers of filter fabrics, New York (1-212-764-7640). Refered to their local representative, A.H. Harris & Sons, Medfield, Mass. 359-7321.

Immediately called. Too busy at that time; but shortly called back. Told that a polypropelene fine mesh filter would be suitable for the purpose I described, and that such a filter would have an indefinite life, protected from sunlight. Material costs for a large quantity would be about 4¢ to 5¢ per sq. ft. Increase to 6¢/sf to allow for laps or stitched seams. I suggested a layer of finer stone to protect the filter from puncture, and he said that ¼" stone should be sufficient. He said doubling material costs for installation would be reasonable. He mentioned that polypropelene floats, and would be a consideration during construction. Man I spoke to was Sean Kiniry.

rek/8006

SA

Sasaki Associates, Inc., 64 Pleasant Street, Watertown, Massachusetts 02172 · (617) 926 3300 Telex 92-2471

RE: Army LIS Dredge - Dredging Costs
SA #8006

MEMORANDUM: BY: R.T. Westcott DATE: 29 September 1978

TO: File

Telephone call to Mr. Mike Rich at Great Lakes Dredging Company, New York City, (201) 964-8070 at 10:55 A.M.

His firm does not do hydraulic pumping. (Gave name of Gibson & Cushman on Long Island, (516) 665-0353, Mr. Chris Kirk, for hydraulic work). Great Lakes does barge work. Very difficult to estimate prices. Bid prices on definite contracts vary by as much as 40%. Factors are: distance to disposal, fuel prices, escalation, etc. I presented the criteria. He gave a figure of about \$3 to \$5/cu. yd. for a barge hauling distance of about 30 miles. An increase of hauling distance from 15 miles to 50 miles might result in a 15% to 20% in hauling cost. These are 1978 prices. Generally go up about 7%/yr. Another constraint is the "tow limit" which refers to the quantity of dredging which can be done before you need to add another scow. Their limit is around 10,000 cu. yd./day. He wondered how suitable hydraulic pumping in a pipeline might be over water.

He said that there is equipment available which could pump the dredge the 20 ft. to go over the top of the dike. Could give not cost figures for this.

SA

Sasaki Associates, Inc., 64 Pleasant Street, Watertown, Massachusetts 02172 · (617) 926-3300 Telex 92-2471

MEMORANDUM:

RE: Army LIS Dredge - Dredging Costs
SA #8006

BY: R.T. Westcott

DATE: 29 September 1978

TO: File

Telephone call to Gibson & Cushman Dredging Company, Long Island Sound, (516) 665-0353 at 11:25 A.M. to Mr. Chris Kirk.

Said that price for hydraulic pumping could be around \$3-\$5/cy for about 3 miles. He said that about 2 miles is practical limit for hydraulic pumping. Nobody would pump farther than that. Said that dredging by clamshell would be out of the question for muck. It would have to be by suction pipe. He said that Great Lakes Dredging is the only firm in the country which has the equipment to pump over the top of the dike. All other equipment is foreign made and Government work does not allow use of foreign equipment. Said possibly an opening could be left in the dike at the beginning to allow a barge to bottom dump at first as there is no current within; but thought the contaminated nature of the dredge would require a sealed container. Perhaps, he suggested, the top 10 ft. of the seal could be left open to allow escape of accumulated water. Said that the mucky nature of the dredging is going to mean that a barge, when full, is going to be about 80% water. Very helpful. Suggested I call anytime.

rek/8006

END

DATE
FILMED

2-83

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